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FOR
TESTING MATERIALS

ORGANIZED IN 1898
INCORPORATED IN 1902

PROCEEDINGS
OF THE
THIRTIETH ANNUAL MEETING

Held at French Lick, Indiana
June 20-24, 1927

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NEW AND REVISED TENTATIVE STANDARDS

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American Society for Testing Materials

ORGANIZED IN 1898
INCORPORATED IN 1902

PROCEEDINGS

PART I

The Society is not responsible, as a body, for the statements and opinions advanced in this publication.

SUMMARY OF THE PROCEEDINGS OF THE THIRTIETH ANNUAL MEETING

French Lick, Ind., June 20–24, 1927

The Thirtieth Annual Meeting of the American Society for Testing Materials was held at the French Lick Springs Hotel, French Lick, Ind., June 20–24, 1927. The following is an analysis of the attendance at the meeting: Members in attendance or represented, 568; guests, 68; total, 636; ladies, 93. The corresponding statistics for the Twenty-ninth Annual Meeting are: Members in attendance or represented, 792; guests, 113; total, 905; ladies, 239.

First Session—Tuesday, June 21, 2 p. m.

Opening General Session

President J. H. Gibboney in the chair.

The President in opening the annual meeting called attention to the recent accomplishments of the Society that seemed to be of unusual interest. He mentioned that the life of the Society was manifested largely in the work of the standing committees and that all of these committees had been quite active during the year and most of them were presenting reports at the sessions of the annual meeting. A review of the committee activities showed an increased interest in the fundamental research of materials. He then cited a number of investigations that seemed to be of outstanding importance from an economic viewpoint, including the work that is being done on the use of metals at high temperatures and on corrosion. He suggested the need for similar work on wear testing since there appeared to be considerable need for sound, thoroughly-planned research in this field. The President then read a cablegram of greeting that had been received from the Czechoslovak Standards Association.

The minutes of the Twenty-ninth Annual Meeting were approved as printed.

The report of Committee E-6 on Papers and Publications, C. L. Warwick, chairman, was presented by the Assistant Secretary. On motion, the report of the committee was adopted.

The report of Committee E-9 on Correlation of Research, discussing briefly the work of the committee during the year and reviewing the various research projects being carried on by the Society's committees and through joint activities, was presented by the chairman, H. F. Moore. On motion, the report of the committee was adopted.

The report of Committee E-5 on Standing Committees, C. L. Warwick, chairman, presenting a number of modifications in the Regulations Governing Standing Committees affecting the procedure of committee work, was presented by the Assistant Secretary. On motion, the report of the committee was adopted.

The report of the Committee of Tellers, consisting of H. E. Smith and J. H. Higgins, appointed to canvass the letter ballot on election of officers, was received. The tellers reported that 988 legal ballots had been cast, the votes being as follows:

For President, to serve for one year: H. F. Moore, 988 votes.
For Vice-President, to serve for two years: T. D. Lynch, 988 votes.
For Members of Executive Committee, to serve for two years:
F. O. Clements, 988 votes.
W. H. Klein, 988 votes.
F. C. Langenberg, 988 votes.
F. N. Speller, 988 votes.

In accordance with the ballot the Chair declared the officers, listed above, elected.

The chairman then requested Past-Presidents A. A. Stevenson and G. H. Clamer to escort the President-elect to the chair. The President-elect, H. F. Moore, expressed his appreciation of the honor of his election to the Presidency and the hope that the Society under his administration might continue the work which had been so brilliantly carried on by his predecessors.

The Vice-President-elect, T. D. Lynch, was escorted to the chair by Past-Presidents J. A. Capp and G. K. Burgess. He thanked the members for the honor bestowed upon him and in doing so stated that he realized that the office was one of responsibility but that with the responsibility came the pleasure of doing things that were worth while, for the work of the Society, as he knew from many years' connection with it, had produced many results that were distinctly worth while and had brought distinction to the Society, both here and abroad.

The meeting then adjourned and the Second and Third Sessions were immediately convened.

SECOND SESSION—TUESDAY, JUNE 21, 3 P. M.

On Wrought Iron, Cast Iron and Magnetic Testing

(Held Simultaneously with the Third Session)

Mr. T. D. Lynch in the chair.

The report of Committee A-2 on Wrought Iron, in the absence of the chairman, H. J. Force, was presented by the secretary, G. H. Woodroffe. The proposed revisions of the Standard Specifications for Lap-Welded and Seamless Steel and Lap-Welded Iron Boiler Tubes (A 83–24), for Staybolt, Engine-Bolt and Extra-Refined Wrought-Iron Bars (A 84 – 24), and for Merchant Bar Iron (A 85 – 24) and of the Standard Definitions of Terms Relating to Wrought-Iron Specifications (A 81 – 21), accepted for publication as tentative in 1925 and 1926, were approved for reference to letter ballot of the Society for adoption as standard as recommended by the committee. The proposed revision of the Standard Specifications for Welded Wrought-Iron Pipe (A 72 – 24), proposed for the first time in 1927 and thus requiring a nine-tenths vote for adoption, were accepted for reference to letter ballot of the Society for adoption as standard. Revisions had been recommended in 1925 and 1926 in the Standard Specifications for Welded Wrought-Iron Pipe (A 72 – 24) and had been accepted for publication as tentative. It was now recommended that the proposed revisions of Sections 1 and 3 be withdrawn and that the remaining revisions of the specifications be adopted as standard. This recommendation was approved and the revisions accepted for reference to letter ballot of the Society for adoption as standard.

The Tentative Specifications for Hollow Staybolt Iron (A 86 – 25 T) were approved for reference to letter ballot of the Society for adoption as standard, as recommended by the committee. On motion, the report of the committee was adopted.

The report of Committee A-7 on Malleable Castings, in the absence of the chairman, W. P. Putnam, was presented by G. H. Woodroffe. The proposed revisions of the Standard Specifications for Malleable Castings (A 47 – 24) recommended by the committee in 1925 and modified as recommended by the committee, were accepted for reference to letter ballot of the Society for adoption as standard. On motion, the report of the committee was adopted.

The report of Committee A-3 on Cast Iron was presented by the chairman, R. S. MacPherran. The report as printed recommended, among others, revisions of the Standard Specifications for Cast-Iron Locomotive Cylinders (A 45 – 14). On the recommendation of the committee these revisions were withdrawn. The remaining revisions, namely, of the Standard Specifications for Gray-Iron Castings (A 48 – 18), for Cast-Iron Soil Pipe and Fittings (A 74 – 18), and for High-Test Gray-Iron Castings (A 88 – 24), were accepted for publication as tentative as recommended by the committee. The proposed Methods of Sampling and Chemical Analysis of Pig and Cast Iron were unanimously accepted for reference to letter ballot of the Society for adoption as standard to supersede the present Standard Methods of Sampling and Chemical Analysis of Pig and Cast Iron (A 64 – 16), this recommendation requiring a nine-tenths vote. On motion, the report of the committee was adopted.

A paper entitled "Tensile and Transverse Strength of High-Strength Cast Iron," by M. E. Greenhow, was presented by H. Y. Carson and discussed.

The report of the Sectional Committee on Specifications for Cast-Iron Pipe, T. H. Wiggin, chairman, comprising a progress report of the organization of the committee, was presented by title.

The report of Committee A-6 on Magnetic Properties was presented by the chairman, Thomas Spooner. The Tentative Methods of Test for Magnetic Properties of Iron and Steel (A 34 – 26 T), revised as recommended by the committee, were approved for reference to letter ballot of the Society for adoption as standard to supersede the present Standard Methods of Test for Magnetic Properties of Iron and Steel (A 34 – 24). The proposed Tentative Methods of Test for Magnetic Properties of Iron and Steel at Low Inductions for Audio and Power Frequencies (A 34 – 27 T) were accepted for publication as tentative as recommended by the committee. On motion, the report of the committee, including the publication as information of proposed standardization of magnetic terms, units and symbols, was adopted.

A paper entitled "The Application of Magnetics to the Inspection of Steam Turbine Bucket Wheels," by J. A. Capp, was presented by the author and discussed.

The report of Committee A-8 on Magnetic Analysis was presented by the chairman, R. L. Sanford. Appended to the report were three papers entitled: "A Method of Graphic Representation of Magnetic Characteristics," by A. V. de Forest, "Magnetic Analysis by Means of the Cathode-Ray Oscillograph," by Thomas Spooner, and "The Duroscope: An Apparatus for the Magnetic Determination of the Durability of Steels," by J. A. Sams, which were presented by the respective authors and discussed jointly. On motion, the report of the committee was adopted.

The meeting then adjourned till 8 P. M.

THIRD SESSION—TUESDAY, JUNE 21, 3 P. M.

On Rubber, Textiles, Coal and Timber

(Held Simultaneously with the Second Session)

Past-President W. H. Fulweiler in the chair.

The report of Committee D-11 on Rubber Products, in the absence of the chairman, F. G. Breyer, was presented by the secretary, E. H. Grafton. The proposed revisions of the Standard Specifications for Rubber Belting for Power Transmission (D 53 – 24), for Rubber Pump Valves (D 151 – 23), and for Adhesive Tape for General Use for Electrical Purposes (D 69 – 24) were accepted for publication as tentative as recommended by the committee. The proposed revisions of the Tentative Specifications for Rubber Insulating Tape (D 119 – 22 T) recommended by the committee were accepted for publication as tentative, the specifications being continued as tentative. On motion, the report of the committee was adopted.

A paper entitled "A Study of the Influence of Moisture on Rubber Testing," by Fred S. Conover and Harlan A. Depew, was presented by Mr. Depew and discussed.

The report of Committee D-13 on Textile Materials was presented by the chairman, W. F. Edwards. The proposed Tentative Specifications for Tolerances and Test Methods for Certain Light and Medium Cotton Fabrics and Specifications and Tests for Cuban (Jute) Raw Sugar Bags and the Tentative Methods for Identification of Textile Fibers and Their Quantitative Determination in Mixed Goods, submitted by the committee, were accepted for publication as tentative. The proposed revisions of the Standard Methods of Testing Cotton Fabrics (D 39 – 24) and of the Standard Specifications for Tolerances and Test Methods for Tire Fabrics Other than Cord Fabrics (D 122 - 25), for Tolerances and Test Methods for Cord Tire Fabrics (D 179 - 25) and Specifications and Tests for Osnaburg Cement Sacks (D 205 - 25), recommended by the committee, were unanimously approved for reference to letter ballot of the Society for adoption as standard, these revisions requiring a nine-tenths vote. The following tentative specifications were approved for reference to letter ballot of the Society for adoption as standard as recommended by the committee:

Specifications for Textile Testing Machines (D 76 - 25 T);
Specifications for Tolerances and Test Methods for Cotton Yarns, Single and Plied (D 180 - 25 T);
Specifications for Tolerances and Test Methods for Cotton Sewing Thread (D 204 - 25 T);
Specifications for Tolerances for Numbered Cotton Ducks (D 230 - 25 T);
Specifications for Tolerances and Test Methods for Electrical Silk and Cotton Tapes (D 259 - 26 T).

The Tentative Definitions of Terms Relating to Textile Materials (D 123 - 26 T) revised as recommended by the committee, were approved for reference to letter ballot of the Society for adoption as standard. The proposed revisions of the Tentative Specifications for Tolerances and Test Methods for Rayon (D 258 - 26 T) were accepted as recommended by the committee, the specifications being continued as tentative. On motion, the report of the committee was adopted.

The report of Committee D-5 on Coal and Coke was presented by the chairman, A. C. Fieldner. The proposed revisions of the Standard Methods of Laboratory Sampling and Analysis of Coke (D 37 - 24) and of Laboratory Sampling and Analysis of Coal (D 22 - 24), submitted for publication as tentative in 1925 and 1926, were approved for reference to letter ballot of the Society for adoption as standard, modified as recommended by the committee. The proposed combination of Standard Methods D 37 and D 22 was approved.

The Tentative Definitions of Terms Relating to Coal and Coke (D 121 - 26 T) revised as recommended by the committee, were approved for reference to letter ballot of the Society for adoption as standard. The proposed Methods of Determination of Sulfur in Coal and Coke by the Bomb-Washing and Sodium-Peroxide Fusion Methods were accepted for publication as tentative as a revision of the combined Methods of Laboratory Sampling and Analysis of Coal and Coke.

The committee submitted the report of a special sub-committee covering the determination of cubic foot weights and sieve tests of crushed bituminous coal that had not been included with the report of the committee as preprinted and asked leave to publish the report in the Proceedings of the Society. On motion, this report was accepted for publication subject to the approval of Committee E-6 on Papers and Publications. On motion, the report of the committee was adopted.

The report of Committee D-7 on Timber was presented by the chairman, Hermann von Schrenk. The Tentative Specifications for Structural Joist, Planks, Beams, Stringers and Posts (D 245 – 26 T), amended as recommended by the committee, were approved for reference to letter ballot of the Society for adoption as standard. These specifications superseded the Standard Specifications for Yellow-Pine Bridge and Trestle Timbers (D 10 – 15) and for Southern Yellow-Pine Timber to be Creosoted (D 24 – 20). On the recommendation of the committee these two standard specifications were accordingly withdrawn. The following tentative methods of test were approved for reference to letter ballot of the Society for adoption as standard as recommended by the committee:

Methods of Testing Small Clear Specimens of Timber (D 143 – 24 T);
Methods for Conducting Static Tests of Timber in Structural Sizes (D 198 – 24 T);
Method of Test for Coke Residue of Creosote Oil (D 168 – 23 T);
Methods of Chemical Analysis of Zinc Chloride (D 199 – 24 T).

The proposed revisions of the Tentative Method of Test for Distillation of Creosote Oil (D 246 – 26 T) were accepted, the method being continued as tentative. On motion, the report of the committee was adopted.

A paper entitled "Standard Fire Tests for Combustible Building Materials," by M. E. Dunlap and Frank P. Cartwright, was presented by Mr. Cartwright and discussed. The paper recommended that the American Society for Testing Materials assign a suitable group or committee to consider the requirements of the situation and develop standard test methods for fire tests of combustible building materials. On motion this recommendation was referred to the Executive Committee for its consideration.

The meeting then adjourned till 8 P. M.

FOURTH SESSION—TUESDAY, JUNE 21, 8 P. M.

Presidential Address, Report of Executive Committee, Testing and Nomenclature

Past-President F. M. Farmer in the chair.

The chairman introduced President J. H. Gibboney, who presented the annual Presidential Address. The President very appropriately called attention to the opportunities for increasing the usefulness of the Society's work. He outlined, for the purpose of emphasis, the present procedure set up by the Society for developing standards to insure that these standards were quite impartial and represented the best interests of both producer and consumer, safeguarding the consumer in securing satisfactory materials since safety was always the paramount consideration. He called attention to the many investigations that were necessary in developing any standards in order to settle moot questions. Having once established satisfactory specifications and methods of test it devolved upon the Society and its committees to see that the amount of energy expended in preparing them was capitalized in the general use of these specifications. He mentioned that there is an ever-increasing trend toward research, which trend was recognized in steps now being taken for the establishment of a research fund, a small sum having been set aside by the Executive Committee this year to serve as a nucleus.

Vice-President H. F. Moore presented the annual report of the Executive Committee which discussed membership activities, the work of the standing committees, publications, finances and administrative matters relating to committee activities and relations with other Societies.

In its report the previous year the need for additional income had been emphasized to cover the ever-increasing publication requirements, the promotion of research and the corresponding increase in office personnel. To provide for this increase in income, on the recommendation of an advisory committee especially appointed to consider the matter, the Executive Committee now proposed that the yearly dues of companies, firms, corporations, industrial associations and commercial testing laboratories be increased from $15 to $30. This involved an amendment of the By-laws and an appropriate amendment of Sections 1 and 3 of Article VII was accordingly proposed as follows:

Amend Article VII, Section 1, to read as follows by the insertion of the italicized words and the omission of those in brackets:

"Section 1. The fiscal year shall commence on the first day of January. *The annual dues, payable in advance, shall be as follows: For Members that are* *companies, firms, corporations, industrial associations or commercial testing laboratories, $30; for all other Members, $15; for Junior Members, $7.50; for Student Members, $3.* [The annual dues shall be $15 for Members, $7.50 for Junior Members and $3 for Student Members, payable in advance.] Honorary Members shall not be subject to dues."

Amend the last sentence of Article VII, Section 3, to read as follows by the insertion of the italicized words and the omission of those in brackets:

> "The cost of membership in perpetuity to *companies, firms, corporations, industrial associations and commercial testing laboratories shall be $600; to other organizations, $300.* [corporations, firms, technical or scientific societies, teaching faculties or libraries shall be $300.]"

On motion, the revisions of the By-laws were accepted and referred to letter ballot of the membership of the Society for adoption.

On motion, the report of the Executive Committee was adopted.

The report of Committee E-8 on Nomenclature and Definitions, Cloyd M. Chapman, chairman, was presented by the secretary, R. E. Hess. The report presented the activities of the committee during the past year in reviewing the various definitions of the Society and in advising with the several standing committees on desirable editorial revisions. The committee recommended the advancement to standard of the Tentative Definitions of Terms Relating to Specific Gravity (E 12 - 26 T) which definitions were under the jurisdiction of Committee E-8. This recommendation was approved and the definitions were referred to letter ballot of the Society for adoption as standard. The committee approved the advancement to standard of a number of tentative definitions recommended by the several standing committees having jurisdiction over the definitions in question. On motion, the report of the committee was adopted.

A paper entitled "Rate of Elongation in Tension Tests," by J. Hammond Smith, was presented by the author and discussed.

A paper entitled "Recent Developments and Applications of the Electric Telemeter," by O. S. Peters, was presented by the author.

The report of Committee E-1 on Methods of Testing was presented by the chairman, J. A. Capp. The chairman called on H. F. Moore to present the portion of the report dealing with the work of the Sub-Committee on Mechanical Testing. This included a report on testing of thin sheet metals. On recommendation of the committee the Tentative Method of Verification of Testing Machines by Means of an Elastic Calibration Bar (E 4 - 26 T) was approved for reference to letter ballot of the Society for adoption as standard to be added to the present Standard Methods of Verification of Testing Machines (E 4 - 24). The Tentative Methods of Brinell Hardness Testing of

Metallic Material (E 10 - 25 T) were approved for reference to letter ballot of the Society for adoption as standard as recommended by the committee. The proposed revisions of the Tentative Methods of Tension Testing of Metallic Materials (E 8 - 25 T) and of Compression Testing of Metallic Materials (E 9 - 25 T) were accepted, the methods being continued as tentative. The committee approved the advancement to standard of the Tentative Method of Test for Distillation of Gasoline, Naphtha, Kerosine, and Similar Petroleum Products (D 86 - 26 T), and of the Tentative Method of Test for Distillation of Natural Gas Gasoline (D 216 - 25 T) recommended by Committee D-2 on Petroleum Products and Lubricants. On motion, the report of the committee was adopted including the publication as information of a comparison of foreign practice with respect to standard tension test specimens for thin sheets.

A paper entitled "Tension Test Specimens for Sheet Steel," by J. T. Nichols, E. S. Taylerson and J. C. Whetzel, was presented by Mr. Nichols.

A paper entitled "Methods for Determining the Tensile Properties of Thin Sheet Metals," by R. L. Templin, was presented by the author and discussed.

The meeting then adjourned till the following morning.

FIFTH SESSION—WEDNESDAY, JUNE 22, 9.30 A. M.

On Steel

(Held Simultaneously with the Sixth Session)

Mr. E. F. Kenney in the chair.

The report of Committee A-1 on Steel was presented by the chairman, J. B. Young. The committee recommended the advancement to standard of revisions presented in 1925 and 1926 of the following standard specifications:

For Silico-Manganese-Steel Bars for Automobile and Railway Springs (A 59 - 16);
For Carbon-Steel and Alloy-Steel Forgings (A 18 - 21);
For Quenched-and-Tempered Carbon-Steel Axles, Shafts and Other Forgings for Locomotives and Cars (A 19 - 21);
For Carbon-Steel Forgings for Locomotives (A 20 - 21);
For Carbon-Steel Bars for Vehicle and Automobile Springs (A 58 - 16);
For Carbon-Steel Bars for Railway Springs (A 14 - 16);
For Chrome-Vanadium-Steel Bars for Automobile and Railway Springs (A 60 - 16);

For Quenched-and-Tempered Alloy-Steel Axles, Shafts and Other Forgings for Locomotives and Cars (A 63 – 21);
For Carbon-Steel Bars for Railway Springs with Special Silicon Requirements (A 68 – 18);
For Boiler and Firebox Steel for Stationary Service (A 70 – 24);
For Lap-Welded and Seamless Steel and Lap-Welded Iron Boiler Tubes (A 83 – 24);
For Welded and Seamless Steel Pipe (A 53 – 24).

Additional revisions were being recommended by the committee in the Standard Specifications for Carbon-Steel Forgings for Locomotives (A 20 – 21) and in the Standard Specifications for Welded and Seamless Steel Pipe (A 53 – 24). The several revisions were approved for reference to letter ballot of the Society for adoption as standard. The revisions proposed by the committee this year in the Standard Specifications for Alloy-Steel Bolting Material for High-Temperature Service (A 96 – 26) were unanimously approved for reference to letter ballot of the Society for adoption as standard, these revisions requiring a nine-tenths vote. By a like vote, the Standard Specifications for Automotive Carbon and Alloy Steels (A 29 – 24) were withdrawn.

The Tentative Specifications for the Manufacture of Open-Hearth Steel Girder Rails of Plain, Grooved and Guard Types (A 2 – 26 T), and for Structural Silicon Steel (A 94 – 25 T) were approved for reference to letter ballot of the Society for adoption as standard. The committee recommended revisions in the following Tentative Specifications, recommending that the specifications as amended be advanced to standard:

For Open-Hearth Carbon-Steel Rails (A 1 – 26 T);
For Carbon-Steel Car and Tender Axles (A 21 – 25 T);
For Low-Carbon-Steel Track Bolts (A 76 – 20 T);
For Cold-Drawn Steel Wire for Concrete Reinforcement (A 82 – 21 T);
For Carbon-Steel Castings for Railroads (A 87 – 22 T);
For Commercial Quality Hot-Rolled Bar Steels (A 107 – 26 T);
For Commercial Cold-Finished Bar Steels and Cold-Finished Shafting (A 108 – 26 T);
For Steel Plates of Structural Quality for Forge Welding (A 78 – 23 T);
For Steel Plates of Flange Quality for Forge Welding (A 89 – 23 T).

The revisions of three of these specifications were further modified. In reference to the Tentative Specifications for Low-Carbon-Steel

Track Bolts (A 76 – 20 T) the requirement on elongation was clarified to indicate that the elongation in 8 in. applied to the full-size rolled bars and a requirement of 22 per cent was inserted for the elongation in 2 in. when the test is made on finished bolts. In reference to the Tentative Specifications for Steel Plates of Structural Quality for Forge Welding (A 78 – 23 T) and for Steel Plates of Flange Quality for Forge Welding (A 89 – 23 T) the proposed revisions of Section 1 were modified to read as follows:

> "These specifications cover steel plates of structural quality (flange quality) suitable for forge welding, without the use of fluxes, where the weld is not reinforced."

With these modifications in the proposed revisions the tentative specifications were approved for reference to letter ballot of the Society for adoption as standard.

The proposed revisions of the Tentative Specifications for Forged or Rolled Steel Pipe Flanges for High-Temperature Service (A 105 – 26 T), for Lap-Welded and Seamless Steel Pipe for High-Temperature Service (A 106 – 26 T) and for Cold-Rolled Strip Steel (A 109 – 26 T), recommended by the committee, were accepted, the specifications being continued as tentative. The committee in its report as preprinted had recommended revisions of the Tentative Specifications for Carbon-Steel Castings for Valves, Flanges, and Fittings for High-Temperature Service (A 95 – 26 T) including the provision that the material should be manufactured by the open-hearth or electric-furnace processes. Upon the recommendation that these revisions be accepted for publication as tentative, A. E. White as representative of the Prime Movers Committee of the National Electric Light Association moved, in view of the somewhat divided opinion that existed with regard to the revised specifications, that the specifications be referred back to Committee A-1 for further study and report to insure that no steps would be taken which would be detrimental to the interested parties. This motion was adopted and the revisions were referred back to Committee A-1.

The committee in its report as preprinted had submitted tentative revisions of the Standard Specifications for Welded and Seamless Steel Pipe (A 53 – 24). These revisions provided for the addition of a new paragraph to Section 2 providing that lap-welded pipe ordered for flanging be given a double welding operation and the addition to Section 6 of a bend test requirement for pipe ordered for flanging. These revisions were withdrawn by the committee as a result of an investigation that had been conducted by Sub-Committee IX on Steel Tubing and Pipe, which was reported upon for the committee by H. H. Morgan.[1] The committee then recommended that the following footnote be added to the specifications as published in the Book of Standards:

"*Double Welding.*—Unless double welded pipe is specifically called for on the order, single welded pipe may be furnished. When double welded pipe is ordered the flattening test on crop ends specified in Section 9 shall be made with the weld on the side."

On motion this recommended revision was approved for reference to letter ballot of the Society.

The proposed Tentative Specifications for Structural Steel for Locomotives and Cars, for Marine Boiler Steel Plates, and for Alloy Tool Steel were accepted for publication as tentative.

On motion, the report of the committee was adopted.

The report of Committee A-4 on Heat Treatment of Iron and Steel, in the absence of the chairman, H. M. Boylston, was presented by the secretary, J. H. Hall. The Tentative Recommended Practice for Carburizing and Heat Treatment of Carburized Objects (A 37 - 25 T) were approved for reference to letter ballot of the Society for adoption as standard to replace the present Recommended Practice for the Heat Treatment of Case-Hardened Carbon-Steel Objects (A 37 - 14).

The proposed Tentative Definitions of Terms Relating to Heat Treatment Operations (Especially as Related to Ferrous Alloys) submitted by the committee were accepted for publication as tentative. On motion, the report of the committee was adopted.

The report of the Joint Committee on Investigation of the Effect of Phosphorus and Sulfur in Steel was presented from manuscript by the chairman, G. K. Burgess. The report presented conclusions drawn from the results of tests on the effect of sulfur on structural steel. On motion, the report of the committee was received for publication.

The report of the Research Committee on Yield Point of Structural Steel was presented by the chairman, M. O. Withey. On motion, the report of the committee was received.

A paper entitled "Embrittlement of Boiler Plate," by S. W. Parr and Frederick G. Straub, was presented by Mr. Parr and discussed.

The report of Committee A-9 on Ferro-Alloys was presented by the chairman, F. C. Langenberg. The following tentative specifications and methods were approved for reference to letter ballot of the Society for adoption as standard as recommended by the committee:

Specifications for Tungsten Powder (A 97 - 25 T);
Specifications for Spiegeleisen (A 98 - 25 T);

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[1] See page 115.—ED.

Specifications for Ferro-Manganese (A 99 - 25 T);
Specifications for Ferro-Silicon (A 100 - 25 T);
Specifications for Ferro-Chromium (A 101 - 25 T);
Specifications for Ferro-Vanadium (A 102 - 25 T);
Methods of Sampling Ferro-Alloys (A 103 - 25 T);
Methods of Chemical Analysis of Ferro-Alloys (A 104 - 25 T).

On motion, the report of the committee was adopted.

The report of the Joint Research Committee on Effect of Temperature on the Properties of Metals was presented by the chairman, G. W. Saathoff. Since preprinting the report, reports had been received on two tests which were presented by H. J. French and N. L. Mochel. On motion, the report of the committee was received.

A paper entitled "Some Tests of a Chrome-Nickel Steel at High Temperatures," by R. S. MacPherran, was presented by the author and discussed.

The meeting then adjourned till 4 P. M.

SIXTH SESSION—WEDNESDAY, JUNE 22, 9.30 A. M.

On Petroleum Products, Insulating Materials and Preservative Coatings

(Held Simultaneously with the Fifth Session)

Vice-President G. W. Thompson in the chair.

The report of Committee D-2 on Petroleum Products and Lubricants was presented by the chairman, F. A. Hull. The following methods of test were approved for reference to letter ballot of the Society for adoption as standard, revised as recommended by the committee:

Test for Analysis of Grease (D 128 - 26 T);
Test for Steam Emulsion of Lubricating Oils (D 157 - 23 T);
Test for Burning Quality of Mineral Colza Oil (D 239 - 26 T);
Test for Thermal Value of Fuel Oil (D 240 - 26 T).

The following methods of test were approved for reference to letter ballot of the Society for adoption as standard as recommended by the committee:

Test for Sulfur in Petroleum Oils Heavier than Illuminating Oil (D 129 - 22 T);
Test for Distillation of Gasoline, Naphtha, Kerosine, and Similar Petroleum Products (D 86 - 26 T);
Test for Burning Quality of Kerosine Oils (D 187 - 24 T);
Test for Burning Quality of Long-Time Burning Oil for Railway Use (D 219 - 26 T);
Test for Distillation of Natural Gas Gasoline (D 216 - 25 T).

The proposed revision of the Standard Method of Test for Water in Petroleum Products and Other Bituminous Materials (D 95 - 24) was unanimously approved for reference to letter ballot of the Society for adoption as standard, this revision requiring a nine-tenths vote.

On the recommendation of the committee, the Standard Method of Test for Specific Gravity of Lubricants (D 47 - 24) was withdrawn.

The proposed Methods of Sampling Petroleum and Petroleum Products, submitted by the committee, were accepted for publication as tentative. The committee in its report as preprinted had also recommended the publication as tentative of a Method of Test for Melting Point of Petrolatum to supersede the present Tentative Method of Test for Melting Point of Petrolatum (D 127 - 24 T). This recommendation, however, was withdrawn by the committee.

The proposed revisions of the Tentative Method of Test for Penetration of Greases (D 217 - 26 T), Test for Detection of Free Sulfur and Corrosive Sulfur Compounds in Gasoline (D 130 - 22 T) and Test for Carbon Residue of Lubricants (D 189 - 24 T) were accepted as recommended by the committee, the methods being continued as tentative. In addition to these revisions the committee presented new revisions of the Tentative Method of Test for Neutralization Number of Petroleum Products and Lubricants (D 188 - 26 T) and Test for Cloud and Pour Points of Petroleum Products (D 97 - 25 T). These recommendations were unanimously accepted and are as follows, the methods being continued as tentative:

Tentative Method of Test for Neutralization Number of Petroleum Products and Lubricants (D 188 - 26 T).[1]—To clarify the meaning the following slight revisions are recommended:

Section 4.—In the second line, change the words "weighed accurately" to read "weighed to 0.1 g."

Section 5.—In the second line, change the words "weighed accurately" to read "weighed to 0.1 g."

Section 6.—In the third line, change the words "weighed accurately" to read "weighed to 0.1 g."

Change the first paragraph under "Procedure" from its present form, namely,

> "Procedure: Pour the oil and water in a 500-cc. separatory funnel. Shake vigorously and after oil and water have separated, drain water into a 500-cc. casserole. Add 100 cc. of boiling water to oil and agitate. Drain separated water to casserole. Repeat washing and to the accumulated 100 cc. of water add 1 drop of phenolphthalein. Boil. If solution turns pink add 1 cc. of the indicator and titrate with the sulfuric acid solution until extraction is colorless."

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 26, Part I, p. 852 (1926); also 1926 Book of A.S.T.M. Tentative Standards, p. 468.

to read as follows:

> "Procedure: Introduce into a 250-cc. separatory funnel 25 to 50 g. of oil weighed to 0.1 g., and add 100 cc. of boiling distilled water. Shake vigorously, and after oil and water have separated, drain the water layer into a 500-cc. casserole. Wash the oil in the separatory funnel twice by vigorously shaking with 50 cc. portions of boiling distilled water and after separation drain into the casserole. To the accumulated 200 cc. of water add one drop of 1-per-cent phenolphthalein solution. Boil. If the solution turns pink, add 1 cc. of the indicator and titrate with the sulfuric acid solution until the extraction is colorless."

Tentative Method of Test for Cloud and Pour Points of Petroleum Products (D 97 - 25 T).[1]—A clarification of the method is recommended as follows:

Section 3.—In the first sentence, change the words "approximately 1¼ in. in inside diameter" to read "1$\frac{3}{16}$ to 1$\frac{5}{16}$ in. in inside diameter."

Change the second sentence to read as follows by the addition of the italicized words and the omission of those in brackets:

> "An ordinary 4-oz. oil sample bottle may be used if [the] *it is within the above requirements, and no* test jar is [not] available."

Section 6.—Change the words "with inside diameter ½ in. greater" to read "with inside diameter ⅜ to ½ in. greater."

Section 12 (a).—In the last sentence, insert the word "upper" before "maximum" and place the latter word in parentheses.

Section 12 (b).—In the first sentence, insert the word "lower" before "minimum" and place the latter word in parentheses.

Section 12 (c).—Change from its present form, namely,

> "The pour point of such oils shall be reported as lying between the maximum and minimum pour points (*e. g.*, Pour Point 35°/50° F.)."

to read as follows:

> "The upper and lower pour points shall be reported separately."

The committee had submitted in the report as preprinted as an appendix to the report of Sub-Committee XXV on Crankcase Dilution a proposed Method for Determining the Percentage of Dilution of Used Crankcase Lubricating Oil. This proposed method was withdrawn by the committee. On motion, the report of the committee was adopted.

The report of Committee D-9 on Electrical Insulating Materials was presented by the chairman, H. S. Vassar. The proposed revisions of the Standard Method of Testing Molded Insulating Materials

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 25, Part I, p. 725 (1925); also 1926 Book of A.S.T.M. Tentative Standards, p. 474.

(D 48 - 24), submitted in 1925 and 1926, were approved for reference to letter ballot of the Society for adoption as standard.

The revisions of the Standard Method of Testing Molded Insulating Materials (D 48 - 24) submitted by the committee for publication as tentative were accepted for publication.

The Tentative Methods of Testing Electrical Insulating Oils (D 117 - 26 T) were approved for reference to letter ballot of the Society for adoption as standard to replace the present Standard Methods of Testing Transformer and Switch Oils (D 117 - 24).

The proposed revisions of the following methods of test were accepted for publication as tentative as recommended by the committee, the methods being continued as tentative:

Testing Untreated Insulating Paper (D 202 - 26 T);
Testing Sheet and Tape Insulating Materials for Dielectric Strength (D 149 - 26 T);
Testing Electrical Porcelain (D 116 - 26 T);
Testing Electrical Insulating Materials for Phase Difference (D 150 - 23 T).

On motion, the report of the committee was adopted.

The report of Committee D-16 on Slate, in the absence of the chairman, D. W. Kessler, was presented by the secretary, D. K. Boyd. The Tentative Definition of the Term Slate (D 247 - 26 T), revised as recommended by the committee, was approved for reference to letter ballot of the Society for adoption as standard. The proposed revisions of the Tentative Methods of Test for Water Absorption of Slate (D 221 - 25 T) and of Flexure Testing of Slate (D 222 - 25 T) were accepted as recommended by the committee, the methods being continued as tentative.

The proposed Tentative Methods of Test for Determining the Insulating Qualities of Slate, submitted by the committee, were accepted for publication as tentative.

On motion, the report of the committee was adopted.

The report of Committee D-15 on Thermometers was presented by the chairman, W. H. Fulweiler. The committee had prepared a proposed specification for the thermometer specified in the Standard Method of Test for Loss on Heating of Oil and Asphaltic Compounds (D 6 - 20). This specification had been submitted to Committee D-4 on Road and Paving Materials, the committee having jurisdiction over the method in question, and was being recommended this year by Committee D-4 for incorporation in the method. The committee reported progress in the preparation of a specification for a thermometer for use in the testing of turpentine. On motion, the report of the committee was adopted.

The report of Committee D-1 on Preservative Coatings for Structural Materials, in the absence of the chairman, Allen Rogers, was presented by H. E. Smith. The Tentative Specifications for Orange Shellac (D 237 - 26 T) were approved for reference to letter ballot of the Society for adoption as standard as recommended by the committee. The following tentative specifications and method of test were approved for reference to letter ballot of the Society for adoption as standard, revised as recommended by the committee:

Specifications for Destructively Distilled Wood Turpentine (D 236 - 26 T);
Specifications for Iron Oxide and Iron Hydroxide (D 84 - 25 T);
Specifications for Chrome Yellow (D 211 - 26 T);
Specifications for Pure Chrome Green (D 212 - 26 T);
Specifications for Reduced Chrome Green (D 213 - 26 T);
Methods of Test for Specific Gravity of Pigments (D 238 - 26 T).

The Tentative Specifications for Raw Linseed Oil (D 234 - 26 T), revised as recommended by the committee, were, after some discussion, approved for reference to letter ballot of the Society for adoption as standard to replace the present Standard Specifications for Purity of Raw Linseed Oil from North American Seed (D 1 - 15).

The revisions of the following standard specifications and methods of test, recommended by the committee, were unanimously approved for reference to letter ballot of the Society for adoption as standard, these revisions, being presented for the first time, requiring a nine-tenths vote:

Specifications for Ocher (D 85 - 24);
Methods of Test for Specific Gravity of Pigments (D 153 - 24);
Methods of Routine Analysis of White Pigments (D 34 - 17);
Methods of Routine Analysis of Red Lead (D 49 - 18);
Methods of Routine Analysis of Yellow, Orange, Red, and Brown Pigments Containing Iron and Manganese (D 50 - 18);
Methods of Routine Analysis of Yellow and Orange Pigments Containing Chromium Compounds, Blue Pigments and Chrome Green (D 126 - 23);
Methods of Routine Analysis of Titanium Pigments (D 186 - 25).

The proposed revisions of the Tentative Methods of Testing Shellac Varnish (D 214 - 26 T) and of Routine Analysis of White Linseed Oil Paints (D 215 - 25 T) were accepted, the methods being continued as tentative. The proposed Tentative Specifications for Boiled Linseed Oil were accepted for publication as tentative as recommended by the committee, to supersede the present Standard Specifications for Purity of Boiled Linseed Oil from North American Seed (D 11 – 15) and the Tentative Specifications for Purity of Boiled Linseed Oil from South American Seed (D 78 – 21 T). The Standard Specifications D 11 – 15 and the Tentative Specifications D 78 – 21 T were accordingly withdrawn. On the recommendation of the committee the following specifications and methods were accepted for publication as tentative:

Specifications for Prussian Blue;
Specifications for Ultramarine Blue;
Specifications for Chrome Oxide Green;
Specifications for Commercial Para Red;
Specifications for Titanium Barium Pigment;
Specifications for Aluminum Bronze Powder;
Specifications for Gold Bronze Powder;
Methods of Sampling and Testing Lacquer Solvents and Diluents.

The proposed Method of Test for Determination of Wax in Shellac ("Machine Made" and Dry Bleached Refined Shellac) was accepted for publication as a tentative revision of the present Standard Methods of Testing Shellac (D 29 – 24). The report of the committee erroneously indicated that the new method was intended to supersede the present Standard Method of Test for Determination of Wax in Shellac (D 29 – 25). On motion, the report of the committee was adopted.

The report of Committee D-17 on Naval Stores was presented by the chairman, F. P. Veitch. The proposed Tentative Method of Test for Determination of Toluol Insoluble Matter in Rosin (Chiefly Sand, Chips, Dirt and Bark) was accepted for publication as tentative as recommended by the committee. On motion, the report of the committee was adopted.

The meeting then adjourned till 4 P. M.

SEVENTH SESSION—WEDNESDAY, JUNE 22, 4 P. M.

Edgar Marburg Lecture

President J. H. Gibboney in the chair.

The President, in opening the session, restated the reasons for the institution of the Edgar Marburg Lecture, and the meaning that was attached to it, namely, that it was for the double purpose of fixing our thoughts on the ideas of the man who contributed so largely to the character of the Society and to receive inspiration from some eminent engineer who in his lecture would bring to the members some phases of recent development in the knowledge of materials. He then introduced the lecturer, Dr. George L. Clark, Professor of Applied Chemical Research and Divisional Director of the Research Laboratory of Applied Chemistry in the Massachusetts Institute of Technology, who chose for the subject of his lecture "The X-Ray Examination of Materials in Industry."

Doctor Clark paid tribute to the memory of Doctor Marburg, mentioning how Doctor Marburg had been so deeply interested in the application of new scientific tools to industry and to the establishment of new standards. In his lecture he spoke briefly of the nature of X-rays and of the application of X-rays in metallography in the location of defects in metal castings, etc. The major portion of his lecture was devoted to a description of more recent applications of the X-ray in the study of crystal structures, particularly by means of the "pin-hole" method. The X-ray had more recently been applied not only to steel and other metals but to non-metals as well, such as wood, rubber and textiles, and gave promise of becoming the most fundamental method of examination of materials.[1]

President Gibboney, in thanking Doctor Clark for his lecture, presented to him on behalf of the Society the Edgar Marburg Lecture Certificate.

The meeting then adjourned.

WEDNESDAY, JUNE 22, 6.30 P. M.

Twenty-fifth-Anniversary Dinner

Past-President W. H. Fulweiler, chairman.

In his opening remarks, Past-President Fulweiler mentioned that the evening had been set aside to do honor to the founders of the Society, to the officers who in the early days had made its successes possible and to the members who had so faithfully carried on the work.

He then read the list of names of the 66 members who had continuously been members since the incorporation of the Society in 1902. In addition to these there were 75 firms and corporations that had held membership since the incorporation of the Society and the names of these companies were then read.

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[1] The Lecture appears in Part II of these Proceedings, p. 5.—ED.

Mr. Fulweiler then presented President J. H. Gibboney, who spoke in commemoration of the Twenty-fifth Anniversary of the Society.

Mr. Fulweiler then recognized Mr. C. L. Warwick, who, as Secretary-Treasurer, presented Mr. Robert W. Lesley, past Vice-President and Incorporator of the Society, Mr. William R. Webster, Incorporator of the Society, and Mr. A. A. Stevenson, Past-President of the Society, for honorary membership. Mr. Warwick referred to the early days of the Society and its predecessor the American Section of the International Association for Testing Materials and the important parts that the several men elected to honorary membership had taken in placing the Society in a secure and sound position. He also called attention to the important positions these men had taken in their respective industrial fields and to their professional attainments. The certificates of honorary membership were then presented to the recipients by President Gibboney. Mr. Richard L. Humphrey represented Mr. Robert W. Lesley, who had found it impossible to attend the meeting, in receiving the certificate of honorary membership. Similarly, Mr. Samuel T. Wagner represented Mr. William R. Webster, who likewise had been unable to attend the meeting. Each of them appropriately acknowledged the honorary membership and in doing so mentioned some of the more intimate and personal phases of the work of Mr. Lesley and Mr. Webster.

Mr. Stevenson was present to receive the certificate of honorary membership in person and in doing so appropriately recounted some of the incidents that took place in the early days of the Society and predicted the important rôle the Society would take in industry in the future.

Mr. Fulweiler then recognized Dr. H. F. Moore, President-elect of the Society, who presented Dr. D. J. McAdam, Jr., to receive the Charles B. Dudley Medal for his paper entitled "Stress-Strain-Cycle Relationship and Corrosion-Fatigue of Metals," presented at the 1926 annual meeting. Doctor Moore called attention to the many valuable publications by Doctor McAdam, in addition to the one for which the Medal was being awarded.

The Medal was presented by President Gibboney. Doctor McAdam expressed his appreciation of the award, in doing so calling attention to the fact that the subject covered by the paper for which the award was made was one of particular interest to Doctor Dudley, since corrosion and failure of metals in service were prominent subjects in the work of Doctor Dudley years ago.

The session then adjourned till the following morning.

EIGHTH SESSION—THURSDAY, JUNE 23, 9.30 A. M.

On Corrosion, Endurance Testing and Wear Testing of Metals

Vice-President H. F. Moore in the chair.

The report of Committee A-5 on Corrosion of Iron and Steel was presented by the chairman, J. H. Gibboney. The report as preprinted recommended that the Tentative Specifications for Hot-Dipped Galvanized Sheets (A 93 – 24 T) be revised and be continued as tentative in their proposed revised form. The committee instead recommended that the specifications as revised be adopted as standard. The specifications were unanimously approved for reference to letter ballot of the Society for adoption as standard as recommended by the committee.

The proposed revisions of the Tentative Specifications for the Coating on Zinc-Coated (Galvanized) Wire and Wire Products (A 110 – 26 T), for Zinc-Coated (Galvanized) Iron or Steel Telephone and Telegraph Line Wire (A 111 – 26 T) and for Zinc-Coated (Galvanized) Iron or Steel Tie Wires (A 112 – 26 T) were accepted, the specifications as revised being continued as tentative.

The proposed Tentative Specifications for Zinc-Coated (Galvanized) Wire Fencing, for Zinc-Coated Chain-Link Fence Fabric Galvanized Before Weaving, and for Zinc-Coated Chain-Link Fence Fabric Galvanized After Weaving were accepted for publication as tentative as submitted by the committee. On motion, the report of the committee was adopted.

The report of Committee B-3 on Corrosion of Non-Ferrous Metals and Alloys, describing the progress that had been made on the committee's program of cooperative tests on various methods of corrosion testing, was presented by the chairman, T. S. Fuller. On motion, the report of the committee was adopted.

The report of Committee D-14 on Screen Wire Cloth was presented by the chairman, R. W. Woodward. The proposed revisions of the Tentative Specifications for Non-Ferrous Insect Screen Cloth (B 50 – 25 T) were accepted as recommended by the committee, the specifications being continued as tentative.

A paper entitled "A Rapid and Practical Method of Applying the Ferroxyl Test to Protective Coatings," by Karl Pitschner, was presented by the author and discussed.

The report of the Sectional Committee on Specifications for Zinc Coating of Iron and Steel, J. A. Capp, chairman, was presented by C. S. Trewin. This report was essentially a report on organization and on motion was received for publication.

The following papers were presented and discussed jointly:

"Effect of Corrosion Upon the Fatigue Resistance of Thin Duralumin," by R. R. Moore—presented by the author;

"Corrosion-Fatigue of Non-Ferrous Metals," by D. J. McAdam —presented by the author;

"Tests of the Endurance of Gray Cast Iron Under Repeated Stress," by H. F. Moore and S. W. Lyon—presented by Mr. Lyon.

A paper entitled "Wear Testing of Metals," by H. J. French, was presented by the author and discussed.

The meeting then adjourned till 8 P. M.

NINTH SESSION—THURSDAY, JUNE 23, 8 P. M.

On Non-Ferrous Metals and Metallography

(Held Simultaneously with the Tenth Session)

Past-President G. H. Clamer in the chair.

The report of Committee B-1 on Copper Wire was presented by the chairman, J. A. Capp. The Tentative Specifications for Soft Rectangular Copper Wire (B 48 – 26 T) were approved for reference to letter ballot of the Society for adoption as standard as recommended by the committee.

The committee recommended that the revisions of the following standard specifications presented by the committee in 1926 and accepted for publication in that year be advanced to standard:

Specifications for Hard-Drawn Copper Wire (B 1 – 23);

Specifications for Medium Hard-Drawn Copper Wire (B 2 – 15);

Specifications for Soft or Annealed Copper Wire (B 3 – 15);

Specifications for Bare Concentric-Lay Copper Cable: Hard, Medium-Hard, or Soft (B 8 – 21);

Specifications for Round and Grooved Hard-Drawn Copper Trolley Wire (B 47 – 25).

The revisions were approved for reference to letter ballot of the Society for adoption as standard.

The proposed revisions of the Tentative Specifications for Bronze Trolley Wire (B 9 – 26 T) were accepted, the specifications being continued as tentative. The committee made the further recommendation not appearing in the report as preprinted that the Standard Specifications for High-Strength Bronze Trolley Wire, Round and Grooved: 40 and 65-per-cent Conductivity (B 9 – 16) be withdrawn. The withdrawal of these specifications was approved.

The report of Committee B-2 on Non-Ferrous Metals and Alloys, in the absence of the chairman, William Campbell, was presented by the vice-chairman, W. H. Bassett. The committee recommended the advancement to standard of the following tentative specifications:

For Muntz Metal Condenser Tube Plates (B 57 – 25 T);
For Manganese-Bronze Ingots for Sand Castings (B 7 – 24 T);
For Manganese-Bronze Sand Castings (B 54 – 24 T);
For Phosphor Tin (B 51 – 24 T);
For Phosphor Copper (B 52 – 24 T);
For Silicon Copper (B 53 – 24 T).

These specifications were approved for reference to letter ballot of the Society for adoption as standard.

The committee recommended the advancement to standard of the revisions of the following specifications and methods that had been submitted in 1925 and 1926 and accepted for publication in those years:

Specifications for Lake Copper Wire Bars, Cakes, Slabs, Billets, Ingots, and Ingot Bars (B 4 – 13);
Specifications for Electrolytic Copper Wire Bars, Cakes, Slabs, Billets, Ingots, and Ingot Bars (B 5 – 13);
Specifications for High Sheet Brass (B 36 – 21);
Methods of Chemical Analysis of Brass Ingots and Sand Castings (B 45 – 23);
Methods of Chemical Analysis of Bronze Bearing Metal (B 46 – 23).

In making this recommendation the committee proposed that the title of the Standard Specifications for High Sheet Brass be changed to read "Specifications for Sheet High Brass." The recommendations of the committee were accepted and the revisions were approved for reference to letter ballot of the Society for adoption as standard. The revisions of the Standard Specifications for Naval Brass Rods for Structural Purposes (B 21 – 19) modified as recommended by the committee were approved for reference to letter ballot of the Society for adoption as standard.

The recommendation of the committee that the following specifications be accepted for publication as tentative was approved:

Specifications for Copper Tubing for Refrigerators;
Specifications for Brazing Solder;
Specifications for Yellow Brass Sand Castings;
Specifications for Bronze Castings in the Rough for Locomotive Wearing Parts;

Specifications for Lined Journal Bearings;
Specifications for Rolled Zinc.

The proposed Tentative Specifications for Bronze Castings in the Rough for Locomotive Bearing Parts and the proposed Tentative Specifications for Lined Journal Bearings were intended to replace the present Tentative Specifications for Non-Ferrous Alloys for Railway Equipment in Ingots, Castings, and Finished Car and Tender Bearings (B 17 - 21 T). The latter specifications were accordingly withdrawn.

The proposed revisions of the Standard Specifications for Cartridge Brass (B 19 - 19) and for Cartridge Brass Disks (B 20 - 19) were accepted for publication as tentative as recommended by the committee.

The proposed revisions of the Tentative Methods of Chemical Analysis of Aluminum and Light Aluminum Alloys (B 40 - 26 T) were accepted, the methods being continued as tentative.

On the recommendation of the committee the Standard Specifications for Light Aluminum Casting Alloys (B 26 - 21) were withdrawn since these specifications had been superseded by the present Tentative Specifications for Aluminum Base Alloy Sand Castings (B 26 - 26 T) and for Aluminum-Base Sand-Casting Alloys in Ingot Form (B 58 - 26 T).

The following papers were then presented and discussed:

"Physical Properties and Methods of Test for Sheet Brass," by H. N. Van Deusen, L. I. Shaw, and C. H. Davis—presented by Mr. Van Deusen;
"Some Useful Applications of a Quartz Spectrograph," by F. A. Hull and G. J. Steele—presented by Mr. Hull;
"Fatigue Studies of Telephone Cable Sheath Alloys," by J. R. Townsend—presented by the author.

The report of Committee B-4 on Metallic Materials for Electrical Heating was presented by the chairman, Dean Harvey. The proposed Tentative Methods of Chemical Analysis of Metallic Materials for Electrical Heating and the proposed Tentative Method of Test for Measurement of Change of Resistance with Temperature of Metallic Materials for Electrical Heating were accepted for publication as tentative as recommended by the committee. On motion, the report of the committee was adopted.

The report of Committee E-4 on Metallography was presented by the chairman, H. C. Boynton. The Tentative Definition of the Term Metallography (E 7 - 26 T) was approved for reference to letter ballot of the Society for adoption as standard to be added to the present Definitions of Terms Relating to Metallography (E 7 – 24). The Tentative Recommended Practice for the Care of the Eyes When Using a Metallographic Microscope (E 2 – 26 T) was approved for reference to letter ballot of the Society for adoption as standard to be added to the present Standard Rules Governing the Preparation of Micrographs of Metals and Alloys, Including Recommended Practice for Photography as Applied to Metallography (E 2 – 24). The revision of the Standard Methods of Metallographic Testing of Non-Ferrous Metals and Alloys (E 5 – 24), submitted by the committee in 1926 and modified as recommended by the committee, was approved for reference to letter ballot of the Society for adoption as standard.

The meeting then adjourned till the following morning.

TENTH SESSION, THURSDAY, JUNE 23, 8 P. M.

On Clay and Concrete Products, and Building Stones

(Held Simultaneously with the Ninth Session)

Mr. S. T. Wagner in the chair.

The report of Committee C-3 on Brick was presented by the chairman, T. R. Lawson. The proposed Tentative Specifications for Building Brick were accepted for publication as tentative as recommended by the committee. These specifications were intended to supersede the present Standard Specifications for Building Brick (C 21 – 20), which on the recommendation of the committee were accordingly withdrawn. The proposed Tentative Specifications for Paving Brick were accepted for publication as tentative as a revision of the present Standard Specifications for Paving Brick (C 7 – 15). The proposed Tentative Methods of Testing Brick were accepted for publication as tentative as recommended by the committee.

The committee presented a resolution on the death of Ira H. Woolson in whose death the committee had suffered the loss of a loyal friend and an invaluable member.

On motion the report of the committee was adopted.

The report of Committee C-4 on Clay and Cement-Concrete Pipe was presented by title. On motion, it was received for publication in the Proceedings.

The report of the Society Representatives on the Joint Committee on Concrete Culvert Pipe was presented, in the absence of Anson Marston and A. E. Phillips, by T. R. Agg. On motion, the report was received for publication in the Proceedings.

The report of Committee C-6 on Drain Tile, presenting results of a research investigation of the need for a form of chemical test for concrete drain tile subjected to alkali and acid solutions, was presented, in the absence of the chairman, Anson Marston, by Duff A. Abrams. On motion, the report was adopted.

The report of Committee C-8 on Refractories, in the absence of the chairman, G. A. Bole, was presented by the secretary, L. J. Trostel. On the recommendation of the committee the following proposed tentative specifications and definitions of terms, as submitted by the committee, were accepted for publication as tentative:

Tentative Specifications for Clay Fire Brick for Malleable Furnaces with Removable Bungs and for Annealing Ovens;
Tentative Specifications for Clay Fire Brick for Stationary Boiler Service;
Tentative Specifications for Clay Fire Brick for Marine Boiler Service;
Tentative Definitions of Terms Relating to Refractories.

The proposed revisions of the Standard Method of Test for Softening Point of Fire-Clay Brick (C 24 – 20) were accepted for publication as tentative as recommended by the committee.

The proposed revisions of the Tentative Method of Test for Resistance of Fire-Clay Brick to Spalling Action (C 38 – 26 T) were accepted, the method being continued as tentative.

On motion, the report was adopted.

The report of Committe D-18 on Natural Building Stones, in the absence of the chairman, F. Y. Joannes, was presented by the secretary, H. S. Brightly. This report was a report of organization and presented an outline of the plans which the committee expected to pursue in carrying out its work. On motion, the report of the committee was adopted.

The report of Committee C-10 was presented by the chairman, D. E. Parsons. The committee in its report as preprinted recommended revisions of the Standard Specifications and Tests for Hollow Burned-Clay Load-Bearing Wall Tile (C 34 – 26) which included increasing the fire resistance period of 16-in. wall specified in Section 6, from 6 to 8 hours. This recommendation was withdrawn. The other revisions were approved for reference to letter ballot of the Society for adoption as standard as recommended by the committee, these revisions requiring a nine-tenths vote since they were being submitted for the first time.

The committee, in recommending the advancement to standard of the Tentative Specifications and Tests for Hollow Burned-Clay Floor Tile (C 57 – 25 T), had recommended among other revisions that a 4-cell 6 by 12 by 12-in. unit be specified in place of the present 3-cell 6 by 12 by 12-in. unit specified in Section 3. The committee now recommended that the 4-cell unit be an additional unit. The revisions as modified were accepted and the specifications were approved for reference to letter ballot of the Society for adoption as standard.

A like modification was recommended in the revisions proposed in the Tentative Specifications and Tests for Hollow Burned-Clay Fireproofing, Partition and Furring Tile (C 56 – 26 T). The revisions as modified were accepted as recommended by the committee, the specifications being continued as tentative.

The meeting then adjourned till the following morning.

ELEVENTH SESSION—FRIDAY, JUNE 24, 9.30 A. M.

On Cement, Lime and Gypsum

(Held Simultaneously with the Twelfth Session)

Mr. Louis Anderson in the chair.

The report of Committee C-7 on Lime, in the absence of the chairman, H. C. Berry, was presented by J. M. Porter. On the recommendation of the committee the following tentative specifications and methods were approved for reference to letter ballot of the Society for adoption as standard:

Specifications for Quicklime for Use in the Manufacture of Sulfite Pulp (C 46 – 25 T);
Specifications for Hydrated Lime for Use in the Manufacture of Varnish (C 47 – 22 T);
Specifications for Quicklime for Use in Water Treatment (C 53 – 25 T);
Specifications for Hydrated Lime for Use in Water Treatment (C 54 – 25 T);
Methods of Sampling, Inspection, Packing, and Marking of Quicklime and Lime Products (C 50 – 24 T)

The proposed revisions of the Tentative Methods of Chemical Analysis of Limestone, Quicklime and Hydrated Lime (C 25 – 26 T) were accepted, the methods being continued as tentative.

The proposed Tentative Specifications for Sand for Use in Lime Plaster were accepted for publication as tentative as submitted by the committee.

A paper entitled "Improved Brick Mortars" by Laurence E. Weymouth was presented by M. L. Hartmann and discussed.

The report of Committee C-11 on Gypsum, in the absence of the chairman, J. W. Ginder, was presented by the vice-chairman, H. E. Brookby. The proposed revisions submitted in 1925 and 1926 and accepted for publication as tentative in those years of the following standard specifications and methods were approved for reference to letter ballot of the Society for adoption as standard:

Specifications for Gypsum Plasters (C 28 – 26);
Specifications for Gypsum Partition Tile or Block (C 52 – 25);
Methods of Testing Gypsum and Gypsum Products (C 26 – 23).

In the report of the committee as preprinted the recommendation appeared that the Tentative Definitions of Terms Relating to the Gypsum Industry (C 11 – 26 T) be advanced to standard, subject to the approval of Committee E-8 on Nomenclature and Definitions. This latter committee had not been able properly to review the definitions and had not approved their advancement to standard. The committee accordingly withdrew this recommendation.

The proposed definitions of the terms Gypsum Molding Plaster, Gypsum Pottery Plaster, and Keene's Cement were accepted for publication as tentative to be added to the present Tentative Definitions C 11 – 26 T. On motion, the report of the committee was adopted.

The report of Committee C-1 on Cement presenting the work that the committee had carried out on tests of fluid water mixtures was presented by the chairman, P. H. Bates. On motion, the report of the committee was adopted.

The following papers were presented by the authors and discussed:

"Long-Time Tests of High-Magnesia Portland Cements," by P. H. Bates;
"The Tensile Strength of Portland-Cement Constituents," by Jasper O. Draffin.

The meeting adjourned till 8 P. M.

TWELFTH SESSION—FRIDAY, JUNE 24, 9.30 A. M.

On Road Materials and Waterproofing

(Held Simultaneously with the Eleventh Session)

Mr. K. G. Mackenzie in the chair.

The report of Committee D-8 on Bituminous Waterproofing and Roofing Materials was presented by the chairman, S. T. Wagner.

The proposed revisions of the Standard Specifications for Woven Cotton Fabrics Saturated with Bituminous Substances for Use in Waterproofing (D 173 - 25) presented for the first time were unanimously approved for reference to letter ballot of the Society for adoption as standard, this recommendation requiring a nine-tenths vote.

On the recommendation of the committee the following tentative specifications and methods of test were approved for reference to letter ballot of the Society for adoption as standard:

Specifications for Asphalt-Saturated Asbestos Felt for Use in Constructing Built-Up Roofs (D 250 - 26 T) revised as recommended by the committee;
Specifications for Asphalt Roll-Roofing Surfaced with Powdered Talc (D 244 - 26 T);
Specifications for Slate-Surfaced Asphalt Roll-Roofing and Slate-Surfaced Asphalt Shingles (D 225 - 26 T);
Specifications for Asphalt Roll-Roofing Surfaced with Granular Talc (D 248 - 26 T);
Specifications for Heavy Weight Slate-Surfaced Asphalt Roll-Roofing and Heavy Weight Slate-Surfaced Asphalt Shingles (D 249 - 26 T);
Specifications for Asphalt-Saturated Roofing Felt for Use in Waterproofing and in Constructing Built-Up Roofs (D 226 - 26 T);
Specifications for Coal-Tar Saturated Roofing Felt for Use in Waterproofing and in Constructing Built-Up Roofs (D 227 - 26 T);
Specifications for High-Carbon Coal-Tar Pitch for Use in Constructing Built-Up Roofs Surfaced with Slag or Gravel (D 251 - 26 T);
Specifications for High-Bitumen Coal-Tar Pitch for Use in Constructing Built-Up Roofs Surfaced with Slag or Gravel (D 252 - 26 T);
Methods of Testing Felted or Woven Fabrics Saturated with Bituminous Substances for Use in Waterproofing and Roofing (D 146 - 26 T);
Methods of Testing Bituminous Mastics, Grouts and Like Mixtures (D 147 - 25 T);
Methods of Testing Asphalt Roll-Roofing Surfaced with Fine or Granular Talc, Slate-Surfaced Asphalt Roll-Roofing and Slate-Surfaced Asphalt Shingles (D 228 - 26 T).

The proposed Tentative Methods of Analysis of Roofing Felt for Fiber Composition were accepted for publication as tentative as submitted by the committee. The committee in its report as preprinted had submitted proposed Tentative Specifications for Asphalt for Use in Constructing Built-Up Roofs and proposed Tentative Methods of Testing Bituminous Materials for Coarse Particles by Elutriation. These two proposed tentative standards were withdrawn by the committee.

The committee recommended the withdrawal of the present Tentative Specifications for Light Body Coal-Tar or Water-Gas-Tar Protective Coating with Solvent Vehicle, for Cold Application, for Damp-proofing Masonry Structures (D 253 - 26 T), and for Heavy Body Coal-Tar or Water-Gas-Tar Protective Coating with Solvent Vehicle, for Cold Application, for Damp-proofing Masonry Structures (D 254 - 26 T). The withdrawal of these two tentative specifications was approved. The committee in its report as preprinted had also recommended the withdrawal of the Tentative Method of Test for Steam Distillation of Bituminous Protective Coatings (D 255 - 26 T). This recommendation for withdrawal, however, was withdrawn.

A paper entitled "The Recovery and Examination of the Asphalt in Asphaltic Paving Mixtures," by John H. Bateman and Charles Delp, was presented by title and discussed.

Attention was called to the fact that in certain papers presented before the Society results of tests were reported that were out of line with the standard tests established by the Society, thus making it difficult to compare the results reported with results that might be reported elsewhere. On motion, it was voted that Committee E-6 on Papers and Publications be asked to consider the possibility of calling the attention of authors to the desirability of reporting results wherever possible in accordance with the standard methods adopted by the Society.

The report of Committee D-4 on Road and Paving Materials was presented by the chairman, Julius Adler. The committee proposed for the first time revisions of the Standard Methods of Test for Loss on Heating of Oil and Asphaltic Compounds (D 6 - 20) and of Mechanical Analysis of Sand or Other Fine Highway Material Except Fine Aggregate Used in Cement Concrete (D 7 - 18). In addition to the revisions appearing in the report of the committee as preprinted it was recommended that a footnote be added to the Standard Methods D 6 - 20 reading as follows:

> "The committee calls attention to the fact that the question of size of oven is now under consideration and that a possible revision of this standard may be expected."

The revisions as modified were unanimously approved for reference to letter ballot of the Society for adoption as standard, this requiring a nine-tenths vote. On the recommendation of the committee the following tentative specifications and methods of test were approved for reference to letter ballot of the Society for adoption as standard:

Specifications for Broken Slag for Bituminous Macadam Base (D 195 - 24 T);
Specifications for Broken Slag for Bituminous Concrete Base (D 196 - 24 T);
Specifications for Broken Slag for Bituminous Macadam Wearing Course (D 159 - 24 T);
Specifications for Broken Slag for Bituminous Concrete (Coarse-Graded Aggregate Type) (D 160 - 24 T);
Specifications for Broken Slag for Bituminous Concrete (Fine-Graded Aggregate Type) (D 161 - 24 T);
Method of Float Test for Bituminous Materials (D 139 - 25 T);
Method of Test for Specific Gravity of Road Oils, Road Tars, Asphalt Cements and Soft Tar Pitches (D 70 - 26 T);
Method of Test for Specific Gravity of Asphalts and Tar Pitches Sufficiently Solid to be Handled in Fragments (D 71 - 26 T);
Method of Test for the Determination of Bitumen (D 4 - 26 T);
Method of Test for the Determination of Proportion of Bitumen Soluble in Carbon Tetrachloride (D 165 - 26 T).

The proposed revisions of the following tentative specifications and method of test were accepted as recommended by the committee, the specifications and method being continued as tentative:

Specifications for High-Carbon Tar for Surface Treatment, Hot Application (D 108 - 23 T);
Specifications for High-Carbon Tar Cement (D 110 - 25 T);
Specifications for Coal-Tar Pitch for Stone Block Filler (D 112 - 23 T);
Specifications for High-Carbon Tar for Surface Treatment, Cold Application (D 104 - 23 T);
Specifications for Low-Carbon Tar for Surface Treatment, Cold Application (D 105 - 23 T);
Specifications for High-Carbon Tar Cement for Use Cold in Repair Work (Cut-Back Product) (D 106 - 25 T);
Specifications for Low-Carbon Tar Cement for Use Cold in Repair Work (Cut-Back Product) (D 107 - 23 T);
Specifications for Low-Carbon Tar Cement (D 111 - 23 T);

Method of Test for Distillation of Bituminous Materials Suitable for Road Treatment (D 20 - 26 T).

On the recommendation of the committee the present Standard Method of Test for Distillation of Bituminous Materials Suitable for Road Treatment (D 20 - 18) was withdrawn.

A paper entitled "Low-Temperature Ductility of Filler-Grade Asphalts," by W. Furber Smith, was presented by the author and discussed.

The meeting adjourned till 8 P. M.

THIRTEENTH SESSION—FRIDAY, JUNE 24, 8 P. M.

On Concrete and Symposium on Field Control of the Quality of Concrete

President J. H. Gibboney in the chair.

A paper entitled "The Use of Lumnite Cement in Short-Time Tests to Determine the Quality of Fine Aggregate for Concrete," by Sanford E. Thompson and Miles N. Clair, was presented by title.

The report of Committee C-9 on Concrete and Concrete Aggregates was presented by the chairman, Cloyd M. Chapman. The proposed revisions of the following standard methods which were being submitted for the first time, thus requiring a nine-tenths vote, were unanimously approved for reference to letter ballot of the Society for adoption as standard as recommended by the committee:

Of Making and Storing Specimens of Concrete in the Field (C 31 - 21);
Of Test for Organic Impurities in Sands for Concrete (C 40 - 22);
Of Test for Unit Weight of Aggregate for Concrete (C 29 - 21);
Of Making Compression Tests of Concrete (C 39 - 25).

The Tentative Methods of Securing Specimens of Hardened Concrete from the Structure (C 42 - 25 T), revised as recommended by the committee, were approved for reference to letter ballot of the Society for adoption as standard.

The proposed Tentative Methods of Test for Percentage of Voids in Fine Aggregate when Inundated, Test for Approximate Apparent Specific Gravity of Fine Aggregate, and Test for Percentage of Surface Moisture in Fine Aggregate were accepted for publication as tentative as recommended by the committee.

Mr. Chapman then called on P. J. Freeman to present the report of the Sub-Committee on Conditions Affecting the Durability of Concrete together with the summary of a paper by G. F. Loughlin presented from manuscript to be appended to the report of the committee as published in the Proceedings.[1]

A paper entitled "A Study of the Data of 'Series 201' and Wisconsin Tests Showing the Relation of the Compressive Strength of Concrete to the Water-Cement Ratio, Space-Cement Ratio and Grading of the Aggregate," by R. A. Nelson, appended to the report of the committee, was presented by M. O. Withey and discussed.

The winners of the Golf and Tennis Tournaments were then announced and the prizes awarded by E. D. Boyer on behalf of the Entertainment Committee. The A.S.T.M. championship golf cup for the low score was won by J. H. Chubb, of Chicago, Ill. The A.S.T.M. championship tennis cup was won by R. J. McKay, of New York City.

Other prize winners in golf and tennis were: H. H. Morgan, H. D. Beattie, E. D. Boyer, H. B. Pullar, A. F. Braid, D. W. Mulford, W. H. Finkeldey, E. W. McMullen, H. A. Bedworth, F. A. Weidman, C. L. Warwick, W. H. McCune and F. S. Crane.

Mr. Cloyd M. Chapman then took the chair and opened the Symposium on Field Control of the Quality of Concrete. In doing so he presented an introduction to the symposium. The following papers entering into the symposium were then presented by the authors and discussed:

"Proportioning of Concrete," by R. W. Crum;
"Mixing of Concrete," by D. A. Abrams;
"Conveying and Placing Concrete," by N. L. Doe;
"Construction Joints and Expansion Joints," by R. L. Bertin (presented by title);
"Insuring Quality Concrete in Cold Weather," by F. H. McGraw (presented by R. E. Hess);
"Transverse Tests as a Criterion of the Quality of Concrete," by H. S. Mattimore;
"The Field Testing of Concrete," by R. B. Young.

There being no further business, the Chair declared the Thirtieth Annual Meeting adjourned *sine die.*

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[1] The complete paper by Mr. G. F. Loughlin is not yet available and accordingly is not included in the Proceedings.—ED.

PROCEEDINGS OF THE TWENTY-FIFTH-ANNIVERSARY DINNER

FRENCH LICK, IND., JUNE 22, 1927

THE CHAIRMAN (*Mr. W. H. Fulweiler*).—Fellow members of the American Society for Testing Materials, ladies and gentlemen: I think we are all agreed that we are met to-night upon a most auspicious occasion, the Twenty-fifth Anniversary of the founding of our Society. Twenty-five years is a long time; many things happen. When we think of all of our successes and of our failures, of the things accomplished, of the things that we have not yet done, when we think of all these material things, I fear at times that we sometimes forget the men who made all of these things possible, and we are going to turn aside to-night for just a few minutes to do honor to the founders of our Society, to the officers who, in the early days, made its successes possible, and most of all, to the members, to the great rank and file of men who put their shoulders to the wheel and did the work.

Friendship, recollections, are the most valuable things we have in this life; the men we meet, the men we know, the men we work with; our memories of them far outlast the recollection of the technical work. When we speak of the founders of our Society, we speak of the seven men whose names appear in our charter. Of the five men who signed the charter, but two are left to us, Mr. Lesley and Mr. Webster; Mr. Merriman, Mr. Colby and Dr. Marburg have gone from us. Mr. Lesley possibly never dreamed of the growth of the organization which resulted when he presented the charter to that meeting in Atlantic City on June 12, 1902. Mr. Howe was chairman of the meeting, and as the result of the organization, Dr. Dudley was elected our first president and Dr. Marburg was elected secretary. While I had not the honor to be a member at that time, still I did have the honor of knowing both of those men and I am proud of it. We all know of the wonderful work that that team did; Dr. Dudley, the father, I think we may well say, of specifications in the United States; and Dr. Marburg, whose memory we are commemorating in our lectures. Following Dr. Dudley as president came Mr. Howe, Mr. Hunt, Professor Talbot, whom we have with us, Mr. Gibbs, Mr. Merriman and Mr. Stevenson. Our officers have done much for us, but to-night we also wish to honor as special guests those men who for twenty-five years have been members of this Society. There are some sixty-six names on our rolls, and I think some eighteen are here with us to-night, and I am going to read their names and ask them if they will not stand up for just a moment that some of the younger men in the Society may see them and may be inspired by the work that has been done.

[Chairman Fulweiler then read the following list of names, and those who were present rose as their names were called (designated by an asterisk (*) in the list).]

Frank A. Barbour.
W. H. Broadhurst.
William H. Burr.
*J. A. Capp.
Louis G. Carpenter.
Charles S. Churchill.
*Guilliam H. Clamer.
Frank H. Clark.
T. L. Condron.
Charles Derleth, Jr.
William Ashton Doble.
*Allan W. Dow
W. C. DuComb, Jr.
Warrick R. Edwards.
A. I. Findley.
Stanley G. Flagg, Jr.
*Charles N. Forrest.
William F. M. Goss.
J. E. Greiner.
N. F. Harriman.
*William K. Hatt.
*E. C. Holton.
*Richard L. Humphrey.
Charles L. Huston.
Alexander Jarecki.
J. Y. Jewett.
Robert Job.
Frank G. Kennedy, Jr.
Gaetano Lanza.
Robert W. Lesley.
Charles F. Loweth.
Andreas Lundteigen.
*T. D. Lynch.
*R. S. MacPherran.
John McLeod.
Richard Moldenke.
William Mueser.
F. H. Neff.
George L. Norris.
Tinius Olsen.
James Madison Porter.
Frederick A. Riehlé.
*A. H. Sabin.
Walter M. Saunders.
Albert Sauveur.
Ralph Martin Shankland.
Porter W. Shimer.
*Jesse J. Shuman.
*H. E. Smith.
Henry S. Spackman.
*A. A. Stevenson.
Bradley Stoughton.
Charles L. Stobel.
George F. Swain.
*Arthur N. Talbot.
*George E. Thackray.
David Thomas.
F. E. Turneaure.
J. L. VanOrnum.
J. A. L. Waddell.
*Samuel Tobias Wagner.
George S. Webster.
William R. Webster.
*H. V. Wille.
Charles B. Wing.
*Walter Wood.

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* An asterisk indicates those who were present at the Dinner.

Besides our individual members we have also some seventy-five firms and corporations who have held membership since 1902, and I am going to read their names. Their representatives are to be considered as our guests to-night. About fifty of them, I believe, are here.

[Chairman Fulweiler then read the names of the following firms.]

†Ajax Metal Co., The.
Allis-Chalmers Manufacturing Co.
Alpha Portland Cement Co.
Altoona Iron Co.
†American Bridge Co.
†American Foundrymen's Association.
American Locomotive Co.
†American Steel and Wire Co.
Atlas Portland Cement Co.
Baldwin Locomotive Works, The.
Baltimore and Ohio Railroad.
†Bethlehem Steel Co., Inc.
†Booth, Garrett and Blair.
Brooklyn Department of Public Works.
†Carnegie Steel Co.
Case School of Applied Science.
†Central Iron and Steel Co.
Chicago, Burlington and Quincy Railroad.
Chicago, Milwaukee and St. Paul Railway.
Chicago and Northwestern Railway.
†Colorado Fuel and Iron Co.
Columbia University.
Concrete-Steel Engineering Co.
†Conwell and Co., E. L.
Cornell University.
†Dixon Crucible Co., Joseph.
†Engineering News-Record.
†Franklin Institute.
General Electric Co.
Harvard University.
†Hunt Co., Robert W.
†Illinois Steel Co.
†International Harvester Co.
Iowa State College.
Iron Age, The.
Jarecki Manufacturing Co., Ltd.
†Jones and Laughlin Steel Corporation.
Lafayette College.
Lehigh Portland Cement Co.
Logan Iron and Steel Co.
†Lowe Brothers Co., The.
†Lukens Steel Co.
Massachusetts Institute of Technology.
National Lead Co.
†National Tube Co.
New York Central Railroad.
New York, New Haven and Hartford Railroad Co.
Norfolk and Western Railway Co.
Ohio State University.
Olsen Testing Machine Co.
†Osborn Engineering Co., The.
Pennsylvania Railroad System.
Philadelphia Department of Public Works.
Phoenix Bridge Co., The.
Pittsburgh Testing Laboratory.
Purdue University.
Reading Company, The.
†Reading Iron Co.
Riehle Brothers Testing Machine Co.
†Roebling's Sons Co., John A.
Sandusky Cement Co., The.
Sellers and Co., Inc., William.
†Sherwin-Williams Co., The.
†Standard Steel Works Co.
Stanford University.
Union Pacific Railroad Co.
University of Colorado.
University of Illinois.
University of Pennsylvania.
University of Wisconsin.
Virginia Polytechnic Institute.
Vulcanite Portland Cement Co.
Washington University (St. Louis).
Westinghouse Electric and Manufacturing Co.
Wood and Co., R. D.

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† Holding company membership continuously since 1902.

At this time it becomes my very pleasant duty to present our President, Mr. Gibboney, who will speak on our Twenty-fifth Anniversary. President Gibboney.

THE PRESIDENT (*Mr. J. H. Gibboney*).—Mr. Chairman, honor guests, ladies and gentlemen: Every anniversary is a significant occasion in the life of an organization. It is a time to turn back the years, so to speak, and by re-examination get a perspective view of our successes and our failures. We may justly take pride in our successes and, if we are wise, we may find profit in our failures.

The twenty-fifth anniversary in the life of our organization is an especially important one, for it seems that through the years our plans and purposes have withstood the test of time, and by duties well done we have proved the right to live and to grow as a helpful part of our industrial life.

As an individual, so an organization grows old, and some exceed their three score years and ten, their usefulness increasing with the years so long as they inspire in each succeeding generations hopes and aspirations for the future. Let us view our hopes and aspirations.

Twenty-five years ago they were outwardly expressed by so-called dreamers, men with visions of service in a field that was little understood. The romances of these early days show our dreamers men of purpose, patience and perseverance, and by fidelity to these virtues has grown this great national organization which to-day is reaching in a helpful way every important industry in the country.

As of old, all men at times dream dreams and see visions, and in our dreams it seems we live somewhere in that great unknown where earth and heaven meet. Dreamers who leave the earth too long are apt to become impractical and of little worth, and just in the same way dreamers who leave the skyline lose the heavenly inspiration and become selfish, sordid and unkind. May we in our dreams fix our thoughts on purposes that will inspire and lead on to a greater service to mankind,

"For a dreamer lives forever,
And a toiler dies in a day."

THE CHAIRMAN.—We now come to what is, to me, an extremely interesting part of our program. In Article 1 of our By-laws, Members and Their Election, Section 5 starts off as follows: "An honorary member shall be a person of widely recognized eminence in some part of the field which the Society aims to cover as defined in Section 2 of the Charter." I would recognize Mr. C. L. Warwick, our Secretary-Treasurer, who will present the candidates for honorary membership. Mr. Warwick.

THE SECRETARY-TREASURER (*Mr. C. L. Warwick*).—Mr. Chairman, honored guests, ladies and gentlemen: The chairman has told you about this occasion, our Twenty-fifth Anniversary, in view of which the Executive Committee has deemed it most appropriate to elect three members of the Society to honorary membership. As the representative of the Executive Committee, it is my privilege, and I assured you, my pleasure, to present these honorary members to you.

Mr. Fulweiler has recounted to you something of the early days of the American Section of the International Association for Testing Materials and of our own Society. The responsibility of incorporating this Society was assumed by seven men, as he has said. Their names will ever be remembered by us, not alone for their vision in those early days but as well for the inspiration that their example has been to us to-day, who must carry on the work they so well began. Those men were Albert Ladd Colby, Henry M. Howe, Charles B. Dudley, Robert W. Lesley, Edgar Marburg, Mansfield Merriman and William R. Webster. Five of these men have passed into the Great Beyond, leaving upon our Society the strong imprint of their genius and their devoted efforts. To-night we delight to honor the two who, through the succeeding twenty-five years, have been with us and who have continued the services so signally begun in the infancy of the Society.

Robert W. Lesley has attained widely recognized eminence in the field of cement. He was one of the pioneers of the cement industry in this country, having begun his connection with the industry in 1874. In 1880 he and associates organized the American Cement Co., which later became one of the largest manufacturers of portland cement. He established the *Cement Age*, now *Concrete*, and edited it for many years. He was the first president of the Portland Cement Association and has recently written and published a "History of the Portland Cement Industry in the United States." With our own Society, his connection dates from the organization of the American Section in 1898, of which he was Treasurer from 1900 to 1902. He is one of the incorporators of the Society, and was its Vice-President from 1902 until 1912. He has always been active in the Committees on Cement and on Reinforced Concrete, and we delight to honor him to-night.

Very much to his regret, and to ours, a visit to Europe planned for some months has made impossible his presence with us upon this occasion. He has asked Richard L. Humphrey to represent him, and most appropriately so. Mr. Humphrey has been intimately and actively affiliated with A.S.T.M. work from the beginning. He was the first Secretary of the American Section of the International Association for Testing Materials, from 1898 to 1900. He has been in close touch with and has himself attained high standing in the fields with which Mr. Lesley has been identified.

Mr. President, ladies and gentlemen, it is my pleasure to present to you Mr. Richard L. Humphrey, the representative of Robert W. Lesley, to receive for him the certificate of honorary membership in the American Society for Testing Materials.

THE PRESIDENT.—Mr. Humphrey, by authority vested in me, it gives me great pleasure to present to you, as Mr. Robert W. Lesley's representative, this certificate of honorary membership.

MR. RICHARD L. HUMPHREY.—Mr. President, I have been asked by Mr. Lesley to convey to you the deep sense of regret he has in not being here and to tell you how very much he appreciates this highest honor which the Society has conferred upon him in electing him to honorary membership. There is a human side to Robert W. Lesley that I believe may not be inappropriately referred to now. In those days when the Society was young, testing was unknown, it was a hard thing to get men to write papers or to deliver them, and it was a very difficult thing in those days to finance the organization. Twenty dollars was pored over for a long time, whether we could spend it or not; in fact, in the early years, the budget amounted to less than three hundred dollars, which is in some contrast to what we have to-day. The membership was less than one hundred, and now it is over four thousand, and at that time men did not look keenly for work in an unknown organization. I remember after our first meeting in 1898 calling on William R. Webster and trying to persuade him that he ought to be chairman of the Committee on Steel, now designated Committee A-1. It took a number of trips to him to sell the idea. I remember calling on Mr. Lesley at that time; we had been having a considerable tussle with the specifications for cement, and when I came in and offered him the position of treasurer of the American Section, he looked to see what sort of catch there was in it, because, knowing the attitude I had on cement specifications, he thought that there must be some trick in this effort. He little knew and I little knew what a momentous occasion that was.

Mr. Lesley was active when I left college; I well remember the scraps that occurred in the Engineers' Club on cement grinding, the burning of cement, when the rotary kiln was considered a dangerous experiment, and later he wrote the famous paper which was presented at the Engineers' Club describing the various specifications.[1] And what a contrast there is between twenty-five years ago and to-day. Twenty-five years ago cooperation between producer and consumer was an unknown thing; every engineer wrote his own specifications;

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[1] Robert W. Lesley, "Cement and Cement Testing," *Proceedings*, Engineers' Club of Philadelphia, Vol. XVI (1899).

he looked askance at the producer of materials as a man trying to fool him. All during that time Mr. Lesley's characteristics of diplomacy stood him in good stead. and he was the first chairman who brought together what is now Committee C-1 on Cement. He was a stalwart in those days.

It is a peculiarly pleasant thing for me to be the conveyor of this certificate of honorary membership to Mr. Lesley. It has been very worthily bestowed. It is a particularly happy occasion that we should take this Twenty-fifth Anniversary to honor these men. This child, the American Society for Testing Materials, had no silver spoon; it was hard work, and the men who served in the early days gave liberally of their time and money to make this Society what it is; and Mr. Robert W. Lesley, in common with all of those men, as a producer, did a yeoman service in making this Society what it is to-day. Mr. President, I want to thank you on his behalf and again I express his regret that he could not be here in person to receive this honor.

THE SECRETARY-TREASURER.—William R. Webster has contributed greatly to our knowledge of the relations between the chemistry and physics of steel. One of the leading engineers of his day, engaged in the testing and inspection of the materials of engineering, he achieved a national, indeed, an international reputation. One of the outstanding accomplishments of his life was the working out of data from which the physical properties of steel could be reliably predicted from its chemical composition, the possibility of which had been seriously questioned in the early days of steel making. This development has had a far-reaching influence on the manufacture of steel. As with Mr. Lesley, Mr. Webster's connection with the society began with the year of its organization as an American Section in 1898. He is one of the incorporators of the Society and he took an active part in the early affairs. He was first chairman of the Committee on Steel—indeed he was its chairman when it was simply a branch of an international committee—and he served in that capacity until 1913. We owe a great deal of the present success of the work of that committee to the foundation he and his fellow officers laid at that time.

He is represented here to-night by one who worked with him in those early days of the steel committee, another of our twenty-five year members, Samuel Tobias Wagner, known to all of you as a leader in the field of railway engineering, an active and outstanding member of our Society.

Mr. President, ladies and gentlemen, it is a pleasure to present to you Mr. Samuel Tobias Wagner, the representative of William R.

Webster, to receive for him the certificate of honorary membership in the American Society for Testing Materials.

THE PRESIDENT.—Mr. Wagner, by authority vested in me, it gives me great pleasure to present to you, as Mr. William R. Webster's representative, this certificate of honorary membership.

MR. S. T. WAGNER.—Mr. President and members of the Executive Committee, ladies and gentlemen: It gives me a great deal of pleasure to be able to accept this certificate of honorary membership for Mr. Webster and to transmit it to him. My only regret is that Mr. Webster is not here tonight to receive it himself. He would receive it much more graciously, and be able to tell you much more clearly than I can just how he feels about it, but I am sure from the knowledge and association I have had with him for many years, that I can at least give you some idea of how much he appreciates it. Mr. Webster and I first came into contact, so far as the A.S.T.M. is concerned, in 1899; that is one year after Mr. Webster joined the Society. I was one year late in getting on board the ship, but Mr. Webster was already at work when I began, and one of my first steps was to associate myself with him on the steel committee, now Committee A-1. I had been in the iron and steel business for some years, and it seemed eminently proper that I should associate myself in that line of work.

In the early days, and for a great many early days on that iron and steel committee there were some really strenuous times. I have heard it said lately that nowadays we do not know what real discussion is. I am sure while that may be so, I have seen a good deal of it lately, but I am sure that from what I saw in the early days of Committee A-1, they surely were real. Those were the days before we knew anything, for instance, about heat treatment of steel. I do not think anybody had any idea in those days what heat treatment of steel was, but I tell you if we had not any heat treatment of steel we had heat treatment in the discussion, and if anybody is here to-night who was at the early meetings of the Iron and Steel Committee, he will remember what those discussions were, and sometimes they come pretty near to what I think the steel people call the "critical temperature." The temperature grew very high, at any rate. Good work came out of all that discussion, and Webster, while he was as fiery as they make them in those days, was working for the Society from the very beginning and I was with him. We were both fighting for the right of the consumers at that time.

Now that brings me to the next thing I want to say. While I have known Mr. Webster and I have known him for quite a length of time, my first contact with him was over forty years ago, and in those times we were not pulling together. I was a representative of a producer in the shape of the superintendent of a bridge fabricating shop, and Webster was an inspector. And sometimes I thought he was a very unreasonable inspector and I told him so very often. But in spite of that ordinary everyday friction, we always were and always have been the very best of friends, and I assure you that those who are now interested in the Iron and Steel Committee may know the yeoman work Webster then did for the American Society for Testing Materials. I therefore shall be very glad in behalf of Mr. Webster to accept this certificate and to transmit it to him and I know he would say, if he were here, that he deeply appreciates it. I thank you.

THE SECRETARY-TREASURER.—And now, ladies and gentlemen, I shall introduce to you one who needs no introduction to this assembly. I know that I am quite safe in saying that he is the most widely known and best loved member of our Society. He is in the steel industry and has been for forty years. He is acclaimed there as a leader. His long and varied experience in the manufacture of steel has brought him many positions of honor and responsibility and I wish to recount to you just a few. He was the first chairman of the Iron and Steel Committee of the American Institute of Mining and Metallurgical Engineers, which is one of the highest positions of honor a man in the steel industry can attain to-day. He has been president of the Association of American Steel Manufacturers, the leading technical organization of the steel industry. His ability was signally recognized during the World War when he was made chairman of the Gun-Howitzer Production Club, which was a group of manufacturers of forgings for large-caliber guns organized to cooperate with the Government in those days of stress.

It is not alone for his eminent position in the steel industry that we honor him to-night. In our own Society he has rendered service of the utmost value. The silver ribbon you see him wearing tells only twenty-five thirty-firsts of the story: he is a "ninety-sixer," which means that he joined the International Association for Testing Materials two years before the American Section was formed. He tells me that he was not especially active in the early days of the Society, but you will agree with me, knowing the man, that that is hard to believe. But I do know that he has been very active in our Steel Committee; he was its vice-chairman for a number of years; and we all know that he was given the toughest assignments in committee work that were at hand in that committee. Indeed, they are more or less historic, and the way in which he handled them, which called for knowledge not merely of things but more particularly of men, has certainly been the admiration of all and I am sure the envy of many of us. He served continuously on the Executive Committee of the Society from 1911 to 1920. In 1916 he was elected our president—an honor that I know he and all of us appreciate the more because it brought to our head for the first time a representative of the producing interests in this organization. In more recent years he has notably served as our representative on the American Engineering Standards Committee, of which he was chairman for two years, and this I assure you is a service for which we are greatly indebted to him. His is indeed a life of devoted service to our organization and to a cause that I know is very, very dear to his heart.

But it is the man himself whom we delight to honor to-night. This is not so formal an occasion but that I may be permitted a personal reference. He was one of the closest friends and advisers of our beloved Doctor Marburg, and I am happy to say that when the responsibilities of the secretaryship of this Society were placed upon me, I inherited that friendship and that same helpful advice, for which I can never sufficiently express my thanks and appreciation.

Mr. President, ladies and gentlemen, it is one of the happiest moments of my life that I am privileged to present to this audience A. A. Stevenson, past-president of the American Society for Testing Materials, to receive the certificate of honorary membership in the Society.

THE PRESIDENT.—Mr. Stevenson, by authority vested in me, and with the affection of the entire membership of the Society, it gives me great pleasure to present to you this certificate of honorary membership.

MR. A. A. STEVENSON.—Mr. President, members of the Society, ladies and guests: A few moments ago the chairman told me that I was nervous. I am, so if I make any breaks, be lenient with me. I do not know what it is about a twenty-fifth anniversary that makes me think of weddings. Yesterday, when our new president was notified of his election and escorted to the platform, he told the story of an incident that happened at the time of his wedding. Now, this ceremony certainly resembles a wedding; I am given away by the Secretary, I am married to the Society by the President, and I get a certificate to prove it.

I certainly do appreciate the honor that has been conferred upon me. I always felt that I had been signally honored when I was elected first president from the ranks of the producers; it was a sort of an unwritten law at that time that a producer should not be president, and I think there was a general feeling that it would be detrimental to the best interests of the Society to have a producer in the presidential chair. It meant a great deal to me, however, because it seemed to be an indication of a growth of more cordial feeling on the part of the consumers towards the producers, and I knew that that would mean much for the work. I wish I could find words to thank you as I should for this and other honors of which I have been the recipient at the hands of this Society. Words fail me, and I can only reiterate and say that I feel from the bottom of my heart and appreciate what you have done.

We have heard quite a little about what men have done for the Society. There is another side of the picture. The question in my mind is what has the Society done for us individually? I think I know we all have profited individually and have made many friends in the work. A short time ago I met a friend of mine, a man who has been a member of the Society for a number of years. Our talk reverted to the work of the American Society for Testing Materials, and he spent about fifteen minutes telling me how he happened to come to his first meeting, how much he enjoyed the work, how valuable had been the information that he had obtained, how much it had helped him in his business. As far as I am personally concerned, among my most cherished memories are the association and friendship of such men as Howe, Merriman, Dudley, Marburg, Hunt and others who are gone, and many of my warmest friendships to-day are those that have been brought about by contacts in the work of the A.S.T.M.

On an anniversary occasion like this, the mind naturally reverts to the past. I remember, for instance, that our finances were slim. In 1898 there were no funds; in 1899, a hundred and twenty dollars were available for expenses, and at the annual meeting in 1899, two hundred dollars was mentioned as having been contributed toward publication and research. It was rather interesting to note that those who were most active in the work in the early stages of the game and who were responsible for our Society at that time, had research uppermost in their minds.

The record of the past is interesting, with its many acrid discussions and its many problems that needed to be worked out, but that is water over the dam. The vital question to-day is, what of the future? The general interest in and knowledge of standardization has become widely disseminated. I think we will all admit that if the present standard of living is to be maintained in this country—a scale of living higher than it ever has been before, higher than history records—is to be continued, every form of conservation must be studied and practiced. I think we will also all admit that a common standard nationally applied would be a great step forward, economically. When the American Society for Testing Materials was organized, standardization was in its infancy; there were few bodies engaged in standardization work. To-day there are something over four hundred and fifty organizations engaged in standardization work. The dictionary of specifications issued by the Bureau of Standards records something like twenty-seven thousand specifications for sixty-six hundred commodities. I think those figures will give you an idea of the problem that is before us to-day. It is not a question of more standardizing bodies or a question of more standards, it is a question of simplification of those we already have. An ideal condition would be a single standard or a common standard for each commodity. It may never be reached, but it is what we should all aim for. In fact, there are movements now that are based on this idea. I would advise every member to read the report of the Executive Committee carefully, and not only to read it but to study it. You will get a better idea of the place standardization is taking to-day.

I heard a story one time that impressed me very much; it was about a lawyer who wanted to engage an office boy. He had the applicants for the position all come to his office at one time. He took them in a room, sat them down and started to tell them a story. He said, "There was a farmer that had been greatly troubled with rats, and one day as he was going out to the barn, he saw a large rat sitting in front of the barn door. The farmer ran back to get his gun, came out, and just as he was starting to aim at the rat, he noticed flames coming from the barn. He dropped his gun, went back and gave the alarm, and then went to see what could be done towards saving the stock and saving what material was in the barn." The lawyer carried his story on for five or ten minutes and finally stopped. The boys sat there, open eyed, with nothing to say, but with one exception, a bright eyed little Irish boy looked up and said, "Say, Mister, what became of the rat?" He got the job. Now I have only one piece of advice to give, and that is to those who are now responsible for the work of the Society: "Keep your eye on the rat." Standardization as far as specifications are concerned, and research as applied to standardization, has been the chief work of the Society. Upon this the Society has been built up, its influence extended and its usefulness enlarged. Again I say, keep your eye on the "rat."

While I was a member of the International Association, and have since 1896 been a member of the American Association, during its existence, and a member of the A.S.T.M. for twenty-five years, in the early days I was not actively engaged in the work, and was not in the councils, and was not one of those who were responsible for the incorporation of the American Society for Testing Materials. With that in mind, I think you will agree that the few remarks I now wish to make in closing can be made with perfect propriety. We owe a debt of gratitude to those men who started this organization. They visualized a new field of work; they saw an opportunity for usefulness to industry and to the country at large. They had the vision and courage to take the step. They had the persistence and confidence to carry on. There were many discouragements, many serious problems, but they met them in a broad minded way and solved them in justice and in fairness. I say then that we owe a debt of gratitude to those men. The way that debt of gratitude can be repaid is to carry on with the same persistence, with the same courage, with the same confidence as those men. Those in charge of the affairs of our Society to-day have many serious problems before them, but knowing many of them as I do, we can feel sure from their interest in the Society, their love of the work, their realization of the ideals, that their decisions will be wise and the results will be even better than have ever been obtained before.

I now wish to close by proposing a toast in which I hope you will all join me; here is to the memory of those who are gone; here is to their associates who are still with us, the men with the vision, with the ideals, with the integrity of purpose, who were responsible for the launching of the American Society for Testing Materials on its voyage in the world. Here is to those who now control its destiny, may they have the same vision, the same ideals, the same integrity of purpose. Having these, we need not fear for the future; we can look for further growth, wider influence and greater usefulness. Here is to the A.S.T.M.

CHAIRMAN FULWEILER.—At its annual meeting in 1925, the Society authorized the establishment of the Charles B. Dudley Medal as an annual award to the author or authors of a paper presented before the Society of outstanding merit, constituting an original contribution on research in engineering materials. This was put into effect last year, and as a consequence we have to present a medal to-night, and I recognize Professor Moore, who will present the author to receive the medal. Professor Moore.

MR. H. F. MOORE.—Mr. Chairman and members and guests: It gives me great pleasure to state that the medallist this year, the first Dudley medallist of the American Society for Testing Materials, is a man who has already made many valuable contributions to our publications. The paper which received the award this year is but one of his many contributions. I am not sure but that the committee which awarded the medal might be criticized for not presenting two medals, for this paper, whose title is "Stress-Cycle Relationship and Corrosion-Fatigue of Metals" presents two distinct achievements in engineering research. The first part of this paper is of special value to the technical testing engineer, describing methods which expedite his work in studying the effect of repeated stress; in the second part of this paper I feel that the author must have had some premonition of this twenty-fifth anniversary with its suggestion of wedding bells, for in this second part he records the result of a pioneer research into the unhappy results which follow from the unholy wedlock of corrosion and repeated stresses. He has told of a danger to materials which I venture to predict will have to be very seriously considered from now on, and he has sounded the first effective note of warning as to this danger. Mr. Chairman, members and guests: It gives me great pleasure to present to receive this first award of the Dudley medal, the metallurgist of the U. S. Naval Engineering Experiment Station, Dr. D. J. McAdam, Jr., an ingenious experimenter, a skillful interpreter of test data, and a master in the special field of fatigue of metals.

THE PRESIDENT.—Dr. McAdam, by authority vested in me, it gives me great pleasure to present to you the first Dudley Medal.

MR. D. J. MCADAM, JR.—Mr. Chairman, ladies and gentlemen: I am especially pleased by the words of introduction by Professor Moore, for whom I have the greatest regard, both professionally and personally. As he was talking, the sentiments that I had could best be expressed in the words that were used by a small colored boy as another colored boy called him a long string of names. He waited quietly until the string of names ceased from lack of vocabulary and breath and then said, "Has you called me all the names that you is going to?" "Yes." "Well then, all dem things you called me, you is."

The work of Charles B. Dudley was broad and varied. He was prominent in many fields of scientific work. He was especially prominent, however, in two fields: one, the failure of metals in service, and the other, the corrosion of metals. His work on the failure of rails in service is well known, extending over many years. In addition to that he did a great deal of work on the failure of parts of machinery, such as car axles, and failures of that type which are now known as fatigue failures. He was not only known widely as a chemist, but also as a metallurgist, and in his work on corrosion, he worked from two points of view, as a chemist and as a metallurgist. It was during his presidency that the committee on corrosion of this Society was organized. So it is a coincidence, or it may be something more, that the paper which was awarded the Dudley Medal covers the subject of corrosion and of failure of materials in service. It may be that there was some influence of the subconscious mind which led the committee to select these two subjects on this appropriate occasion. The psychologists tell us that the subconscious mind influences our decisions without our knowing it, so that it may be somewhat more than a coincidence that the choice fell on these subjects. That is merely a hypothesis, not a theory. However that may be, I am deeply conscious of the privilege and honor of receiving this medal. I wish to express my thanks to the committee on awards, to the Executive Committee, to Professor Moore and to our honored president and to all the members of the Society.

[The meeting then adjourned.]

ANNUAL ADDRESS BY THE PRESIDENT

JAMES H. GIBBONEY

JUNE 21, 1927

This meeting marks the twenty-fifth anniversary of the Society under its charter of incorporation. It is eminently fitting that we should pause at this time to recall some of the incidents leading up to this event, and from a review of some of our accomplishments, gain inspiration for the future development of our work.

The American Section of the International Association for Testing Materials was organized on June 16, 1898, with about seventy members, and this group of testing engineers for several years cooperated in a very helpful way with the parent society in an endeavor to stimulate interest in the study of engineering materials in this country, as well as to interpret our thoughts in such matters to our European co-workers. It was soon realized, however, that this arrangement was not bringing about the degree of interest that had been anticipated, and that an independent organization could best carry out the objects in view. So on April 12, 1902, an application for a charter incorporating as the American Society for Testing Materials was approved by the Executive Committee, and this charter was formally accepted and ratified at the annual meeting of the Section on June 12, 1902.

The Section had shown a very gratifying growth in membership during the four years of its existence. However, with incorporation and with the election of an active permanent secretary the work took on increasing vigor and interest, as indicated by a doubling of the membership in the succeeding year, and the formation of a number of technical standing committees to undertake definite lines of investigations in materials.

From the very beginning the purposes of the Society have been clearly defined, and through fidelity to these purposes we have been able to bring about the wholesome cooperation between the producer and user of materials as has given our standardization work its widespread recognition. The growth of the Society has been a stable and gradual process reflecting increased activities and entry into new fields of work, and we now speak with pride of a national organization of over four thousand members, serving industry in keeping with the remarkable growth of our country, and in a manner that singles us out as the one organization dealing with engineering materials best qualified in the development of standards for materials.

The early activities of the Society were directed in a very large measure toward the solution of problems vitally affecting the safety of life, particularly in the field of transportation—the steel rail, structural steel for bridges and buildings, cement and concrete being among the most prominent materials investigated. It is very interesting to find that the men who contributed to the solution of the problems at that time have continued with us through the years, many of them now lending their sympathy and encouragement in carrying on the work.

Twenty-five years ago industry was just beginning to be awakened to the value of technical research, and much of the early romance of the Society is to be found in the efforts of our members to stimulate interest in the fundamentals concerning the production of engineering materials and the economies that might be realized in the proper utilization of technical information. We find that even in our early standardization work there was a spirit of tolerance and appreciation for the scientist, despite the fact that in many industries the chemist and the metallurgist were considered dreamers. It is therefore not surprising that through the efforts of our founders, scientific knowledge was gradually introduced in the manufacture of many materials with resulting economies.

The standardization work of the Society has been a very logical development comprising in general four steps, namely, (1) the development of methods of testing materials, (2) the setting up of standard definitions and statements of nomenclature, (3) the formulation of specifications defining the quality and tests of materials, and (4) the preparation of recommended practices governing certain processes in the utilization of materials.

The actual work of developing standards is, as we know, the work of committees, and since the making of specifications for materials has been one activity that has given us possibly our greatest opportunity for cooperating with industry, it would be well to see just how carefully our founders planned to construct these committees and set up rules of procedure that would safeguard all interests concerned.

The Society is made up largely of two groups of members of equal privileges. These groups are fairly definitely classified as producers and consumers of materials, together with a somewhat smaller but very vital group of investigators, teachers, etc., who have expert knowledge of materials, but being neither producer nor consumer may be said to have a general interest in engineering materials. In the early days of the Society the processes of manufacture were fairly simple and could be varied somewhat at will to meet the ideas of individual consuming groups. It is quite obvious, however, that our rapid industrial development of recent years has brought about a high degree of specialization, wherein the finished products of one industry become the raw materials of another. This natural process has introduced economic considerations of far-reaching purport that must be carefully weighed in the making of standards.

The producer is, of course, largely concerned with the making of the material and the consumer with its use. But both are working to a common purpose, each with special knowledge that is invaluable to the other in arriving at a desired result. It is on this principle of mutual interest and cooperation that our Society has constructed its plans for developing commercial standards, and all standing committees dealing with specifications and methods of testing must have adequate representation from both the producing and consuming groups. It is recognized that the consumer has in many instances a legal or quasi-legal responsibility to the public in the use of engineering materials, and from the very beginning our regulations have accordingly required that all committees dealing with commercial problems shall have a consumer member as chairman, and, similarly, that the producer group shall not predominate.

At the present time we have forty-five standing committees with about fifteen hundred members, and these committees are serving in an active and most helpful way practically every important industry in this country. Our Society is the only national engineering organization of its kind primarily interested in the development of standards for materials whose procedure has been established by regulation on a strictly cooperative and voluntary plan, and in view of this fact it would be of interest to outline the important steps that are followed in the development of a specification for any given material.

It is first necessary to agree upon acceptable methods of determining the various properties of the material. This usually involves conducting a large number of cooperative tests by various methods. There should be agreement as to accepted definitions of terms relating to the particular group of materials, products and processes involved. The committee then discusses requirements of proposed specifications. Here full account must be taken of the effect of manufacturing processes, the nature of stresses and other conditions to which the material will be subjected in service, and the particular properties of the material that enable it to give satisfactory service. Painstaking investigation and study of experience accumulated over years of service are often required before an adequate specification can be prepared. The committee must come to agreement upon the properties of the material to be specified, the methods of test to be applied, such details of manufacture as may be necessary, methods of inspection and of marking, and so on. In all of these things it seeks to follow the best commercial practice that has been developed in supplying the particular material or commodity to the trade. Specifications for materials upon whose strength and reliability the safety of human life may depend must be especially carefully drawn and provided with adequate safeguards in testing and inspection. At times a compromise between the somewhat extreme views that may be held by producer and consumer is necessary in reaching at least a tentative agreement upon certain details, although the more clearly the problems involved are understood and the more complete are the technical data that can be presented on the subject, the more easily can a logical, rational agreement be reached.

After full consideration at meetings and final action by "letter ballot" of the entire committee, the proposed standard is presented to the Society for discussion and is published for at least a year as "tentative." In that status it is, so to speak, on trial by industry, where either its suitability will be established or desirable modifications be indicated.

When a "tentative" standard either has been found acceptable or has been suitably revised by appropriate committee action, it may be proposed to the Society at an annual meeting for adoption as "standard," which requires a "letter ballot" vote of the Society membership.

Revisions of standards may be considered at any time, since the committees are continuing committees responsible to the Society for the standards they have formulated. The procedure for revisions is substantially the same as for new standards.

It is appreciated that many of you are already informed concerning the procedure of our committee work. However, a restatement of these facts at this period in our history affords an opportunity to again reaffirm our faith in these plans. From time to time this procedure has been questioned by some who perhaps have seen but a part of the picture and who, from such imperfect contact, have been prone to criticize the activities of certain groups in developing specifications for materials, attributing to them motives of a selfish and commercial nature. It has been my good fortune during the past twenty years to have participated actively as a consumer in many of the important standardization projects of the Society, and this intimate contact has afforded the very best opportunity to judge the motives that have brought about so many of our accomplishments. At times it is true the interests involved have been far-reaching and the lines have been sharply drawn, and yet in every vital issue the finer elements of good judgment and generosity have prevailed, and I welcome this opportunity to stamp the accusation that our work is in any measure influenced by ulterior motives or dominated by the manufacturing groups as wholly unfair and without the slightest foundation in fact. On the contrary, much of the splendid research work in the fundamentals of materials that has given such outstanding permanence to standardization work in this country has been made possible largely through the sympathy and support of the testing engineers connected with our cooperating industrial groups.

Several years ago the greater need and appreciation of increased research activities in our Society work was developed in a most striking way in a presidential address, and as the result of this impetus many of our committees set up small groups charged with fundamental research on problems affecting their specification work. A review of our committee work for 1926 appearing in the A.S.T.M. Bulletin issued in January of this year indicates in just what measure we are producing researches that are directly related to standardization problems.

From time to time questions must arise that demand accurate experimental data before satisfactory requirements and suitable methods of testing can be written into specifications, and it goes without saying that we must continue to encourage the proper appreciation of such research activities if our future work has the degree of usefulness and permanence that is so much desired.

The establishment of a Research Fund for the support of investigation work has long been recognized as a vital need in our committee work, and it is with genuine satisfaction that the Executive Committee is reporting this year that such a fund is now a reality. The favorable financial balance at the end of 1926 made it possible to set aside $1000 as the beginning of this fund, and we are hopeful that when our purposes and plans are better known to industry at large we may have substantial additions to this fund in the form of gifts or legacies from those interested in fundamental work in engineering materials. In general, our committees must continue to finance specific investigations as they have done in the past, and we should not overlook in this connection the generous support that we have had from our membership in recent years in conducting our research programs. It is such evidences of confidence as these that lead us to feel that industry has placed its stamp of approval on our fidelity in administering research investigations. As the newly-established fund grows, our work may surely be enlarged and become a still more potent factor in the development of useful knowledge of materials.

Committee E-9 on Correlation of Research has had this development in mind in its studies of our research activities, and while seeking means for encouraging a healthy interest in the projects now under way in our committees it is also looking ahead to determine useful, unexplored fields for future work. One of the present outstanding problems which they are now considering, and which should have the intense interest of the testing engineer, without further delay, is the matter of wear studies. Wear losses in practically all lines of industry represent possibly the greatest form of economic waste in materials, and we should look hopefully to our members to arouse the interest that will lead to sound and thoroughly planned researches in this important field of work.

The importance of the study of materials under actual conditions of use has long been recognized as one of the strongest means of assurance in determining the suitability of a material for a given service. This method of testing has been a safeguard of the greatest importance. It has been our observation, however, that both the producers and the users of materials have in many instances failed to profit by this source of information for lack of proper contacts that would develop increasing interest and confidence between the engineers of the two parties concerned.

In the field of experimental research we may frequently find the solution of some of the most intricate problems by the study of materials that have failed to function in service in the manner anticipated. Too frequently both the producer and the user of materials are willing to accept a certain degree of failure as a quite natural result and find satisfaction in data that show but few failures in service.

Failures in materials often carry lessons that may be turned to profitable use, and no better examples of this sort of application could anywhere be found than in the methods followed by the railroad with which I am connected in the study of broken parts. A very striking illustration of just what can be accomplished by this sort of research, which is but one of many problems studied in the past few years, had to do with locomotive side rod consumption. During 1925 we found that the consumption of rod forgings was running into very high figures and an analysis of the situation developed the information that a large number of rods were breaking, others were being removed due to cracks detected in inspection, and still others were found unfit for service from other causes. As the result of this study the means for improvement seemed to be along the following lines: strengthening of the design, selection of a material capable of developing high stress and shock resisting properties, closer supervision in forging, heat treating and final machining in manufacture, eliminating of abuse in the roundhouse by intensive education, and finally a careful control of stock to eliminate excessive surplus of manufactured rods.

The study of actual failures naturally led to points of weakness in design and necessitated many changes, and in some cases slightly heavier rods were adopted. Researches in the laboratory suggested the use of a simple alloy steel as a more satisfactory material for higher stress conditions, thus providing greatly increased strength with only slight increases in weight.

At the same time technically trained apprentices were placed in the forging and machine shops charged with seeing that shop practices were made to conform strictly with approved methods, and all forgings were carefully tested according to standard inspection practices including micrographs of each normalizing charge.

A program of education for shop and roundhouse forces was inaugurated, directing special attention to the importance of certain refinements in finishing and the elimination of abuse or rough-handling in the roundhouses. Simple instructions outlining the proper way of handling the material were made impressive by pointing out certain recognized bad practices that had resulted in failure, such as rupture of surface metal by heavy sledging giving rise to progressive fractures, sharp shoulders, and improper fits. Identification markings made with chisel or center punch were prohibited and all such markings were located on grease-cup projections. Each failure was analyzed and complete reports including photographs were broadcast to all of our shops, such reports being made particularly elaborate where the failure was the direct result of shop or roundhouse abuses.

This program was started about the middle of 1925, and by the end of the year was well under way without, however, any definite results as yet being manifested. The consumption during 1925 amounted to 784 rods of an average weight of 414 lb. each or 14.8 lb. for every 1000 locomotive miles. However, early in 1926 we began to realize returns and the consumption figure for this year was reduced to 394 rods of an average weight of 448 lb. each or 7.4 lb. for every 1000 locomotive miles or just exactly one-half the figure for 1925. During the first four months of the present year, this figure has dropped to 4.5 lb. per 1000 locomotive miles, which is less than one-third of the figure of two years ago.

Studies such as the one just outlined, and many others which make up our daily tasks, are very definitely in the field of the testing engineer, and if we are to measure up to our full responsibilities we must seek with increasing diligence the causes leading to unsatisfactory results in the uses of materials. It has been our experience that if problems of this kind are approached with an open mind and a proper understanding of the important factors involved, it is a matter of fairly ready determination whether the failures are due to unsatisfactory properties inherent in the material or to improper fabrication or abuse in use. We have no patience with the somewhat prevalent practice of manufacturers making replacements of materials failing in service as a matter of policy in keeping a customer satisfied. This method is wholly unsound and will, of course, lend no improvement to any unsatisfactory service situation. The only relief will be found in seeking out the true causes of failure and correcting the unsatisfactory conditions, and this is the function of the testing engineer and not that of the sales and purchasing departments.

It will be recalled that the Society at the annual meeting last year approved the establishment of the student grade of membership, and it is interesting to report that three young men have taken out membership of this grade during the past year. Many of our large industrial organizations have had special apprentice training courses for some time, and these courses have attracted yearly numbers of graduates from our engineering schools. Those of us who have come in contact with these young men have been impressed with their lack of any definite ideas of standardization or knowledge of specification making in its simplest form as applied to the most common of structural materials. There seems to be no question but that our schools should give their students some information of this sort, and it was a desire to enlarge our usefulness to the engineering schools that led in the establishment of student membership, whereby the senior and post-graduate student could affiliate with us at a very nominal cost, and thus obtain the very best information that is being developed in research and specification work in the field of engineering materials. It will be a fine thing if we can now get the teachers in the technical schools who are members of the Society really interested in telling their students about the A.S.T.M., what it is doing in the technical and industrial world, and how the students can and should make use of our work when they go out, and also to encourage them to affiliate and help do the work that is before us.

In this same connection I should like to bring to the attention of our committees the impressive teaching value of experimental research and the possibilities of extending such work at educational institutions affiliated with us. Some of our engineering schools have splendid facilities to undertake research problems for our committees, and the type of student we are seeking to interest in our work is often in close touch with experimental work that is being done in college laboratories. We should encourage more definite contacts with technical colleges wherever such contacts give promise of mutual value, in the conviction that such work will broaden the vision of the teacher and the advanced students in the practical significance and economical importance of researches in materials. Where practical our committees might, with great profit, extend such cooperation to the installation of field tests on college grounds, and such tests as these will serve to impress the student with the practical side of research far beyond mere statements made by the teachers in the class rooms. Committee A-5 on Corrosion of Iron and Steel had this thought very definitely in mind when it established one of its field test racks at Pennsylvania State College, and at the time of its last inspection of these tests the members had the opportunity to give the advanced students in metallurgy some thoughts concerning the planning of service tests, the truths they were endeavoring to establish and the economic importance to industry of the accurate determination of such facts.

In closing, may I take advantage of this anniversary occasion to felicitate our committees on their splendid accomplishments in recent years. A glance at the personnel lists in the Year Book will convince one that all of our committees are broadly organized to do their work in a most effective way, and their activities are abundantly attested by the many comprehensive reports presented at this meeting. Where else can we look with greater hope of accomplishment in the development of useful knowledge of materials than to this young and virile national testing fraternity. We may be glad to have our fellow co-workers in other fields judge us by our works, and with this restatement of the faith that is within us concerning our plans and purposes, we may take courage for greater usefulness, in the confidence that the things we are seeking to do will contribute in no small measure to the future happiness and well being of mankind, by making this world a better and a safer place for us and for our children to work out their destinies.

ANNUAL REPORT OF THE EXECUTIVE COMMITTEE

The year just closing has been a very busy one for the Society. It marks also the completion of the twenty-fifth year since the incorporation of the Society, the Charter having been granted on June 4, 1902, and ratified at the annual meeting on June 12 of that year. It is planned suitably to commemorate this occasion during the present annual meeting.

Another event of importance is the holding of an annual meeting in the Middle West for the first time. Every effort has been made to make the meeting a memorable one not alone from the technical side but also from that of sociability. The Committees on Annual Meeting, Transportation and Entertainment have been particularly active in promoting the arrangements for the latter.

Many questions of importance have engaged the attention of the Executive Committee in directing the affairs of the Society during the year and are set forth in more or less detail in this report. Some questions of committee procedure have been discussed jointly with Committee E-5 and have led to modifications in the Regulations Governing Standing Committees; other questions are still under consideration. The auditors report for the fiscal year of 1926 shows a surplus of over $36,000, of which approximately $22,000 is invested as permanent reserve. In addition, slightly over $11,000 is held as a reserve for 1927 publications. A plan for increasing the income of the Society is proposed in order that the Society shall be better able to publish the constantly increasing volume of standards and of important data on properties of materials that come to it yearly through its standing committees and members, and in general to render increased service to its members and to industry.

The Dudley Medal and Marburg Lecture Fund has been completed. The award of the Medal and the giving of the Lecture will from now on be significant features of each annual meeting and it is believed will stimulate our work in promotion of knowledge of materials. Researches by committees of the Society have gone forward in a very gratifying way. International attention will again be focused on properties and tests of materials through the holding of an International Congress for Testing Materials in the fall of this year—the first to be held since the 1912 meeting of the International Association for Testing Materials in New York City.

Standardization in both its national and international aspects has been a subject of active consideration. The standardization movement has developed rapidly during the past decade in many industries and in this development has brought problems of adjustment and coordination that require study. The formation of a Committee on Standardization Survey, primarily from the point of view of national standardization, is noted in this report. Again, there is a proposal to form an international standards association, and the nature of American participation in such an association, involving the American Engineering Standards Committee and the U. S. National Committee of the International Electrotechnical Commission, upon both of which the Society is represented, is now under consideration.

The cooperative relations with other organizations are always an important feature of the Society's activities and have been enumerated in the report.

Membership:

The membership of the Society at the time of this annual meeting is 4220. Statistics for the year are shown in the following table:

	1926 Annual Meeting	1927 Annual Meeting	Losses				Additions		Totals		
			Transfer	Resignation	Dropped	Death	Transfer	Election	Loss	Gain	Increase
Honorary Members	2	5	..	...	...	..	3	...	...	3	3
Members	3920	4143	3	126	110	13	25	450	252	475	223
Junior Members	78	68	25	2	6	..	..	23	33	23	10[a]
Student Members	....	4	..	..	...	..	..	4	...	4	4
Total	4000	4220	28	128	116	13	28	477	285	505	220

[a] Decrease.

The net increase in membership for the year now ending is 220, which compares with 284 for the year ending with the 1926 annual meeting and 235 for the preceding year. The number of new members elected during the year, 477, is somewhat lower than that for the preceding year, 535, and about the same as two years ago, 480. This slight falling off is probably due in part to the establishment of entrance fees last September.

A continued healthy growth in membership such as the Society has enjoyed over a period of years, as illustrated in Fig. 1, is important, and the members render the Society a significant service in interesting others in our activities. The efforts of our standing committees in this direction have been particularly helpful, in that they have resulted in widening the circle of influence of the Society. The various efforts that are made to increase the membership have been reported from time to time in the Bulletin. Membership among municipalities and technical schools has been materially extended during the year.

Last fall a new grade of Student Member was established. For various reasons it was necessary to postpone active efforts to bring this new class of membership to the attention of students in the technical schools; but this work will be taken up vigorously at the opening of the next college term. The aid of a number of our members in these schools who are favorably disposed to the plan will be sought.

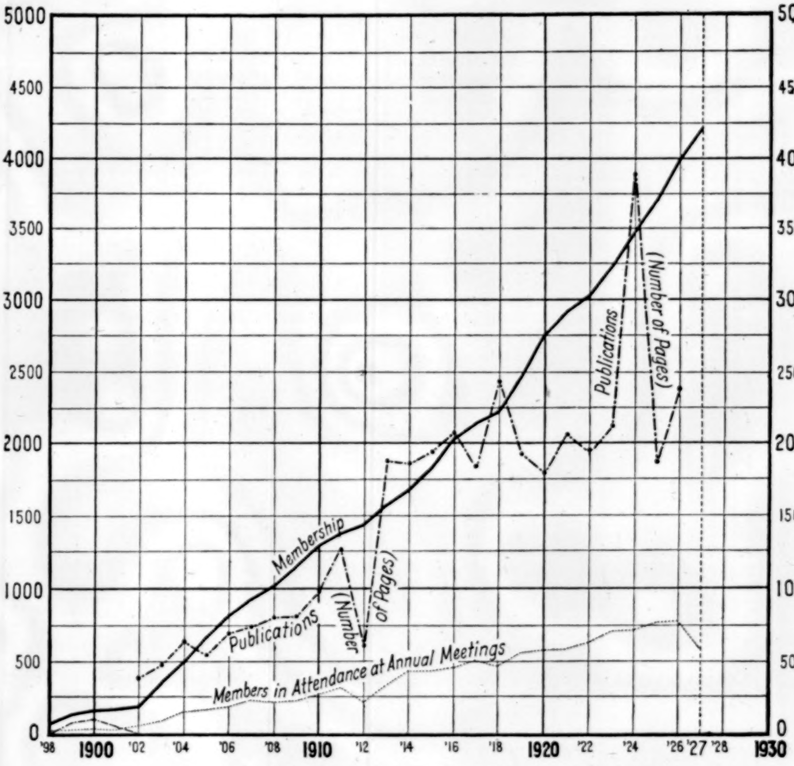

FIG. 1.—Membership and Publication Chart.

At its meeting on April 12, 1927, the Executive Committee elected three Honorary Members of the Society, Robert W. Lesley, William R. Webster and A. A. Stevenson. The formal presentation of certificates of honorary membership will be made at the Twenty-fifth-Anniversary Dinner during the annual meeting.

The Society has suffered the loss by death of thirteen members, as follows:

W. C. Adams
G. A. Drysdale
G. K. Elliott
C. E. Fox
R. J. Giblin
W. G. Gibson
Geo. Matheson, Jr.
L. J. McGrath
T. A. Randall
T. S. Sligh, Jr.
A. B. Steen
N. B. Trist
I. H. Woolson

Committee Activities:

Since the last annual meeting no new standing committees have been organized, so that the number of committees remains at 45. The year has been one of much activity by the committees and 40 of the standing committees are presenting reports to the Society this year. Many of these record substantial progress in researches and studies that are under way in the committees, and a statistical examination of the recommendations of the committees shows that our work in the promulgation of standards for materials is fully as big and important as in any previous year of our history. The committee reports include recommendations for revisions in 70 standards, the advancement of 95 tentative standards to standard, the acceptance of 45 proposed new standards as tentative and proposed revisions in 41 tentative standards to be continued as tentative. There are at present 497 standards and tentative standards of the Society and if the recommendations of the various committees are approved this number will become 515.

The titles of two committees were changed during the year. That of Committee C-5 on Fireproofing was changed to Fire Tests of Materials and Construction and that of Committee C-4 on Clay and Cement-Concrete Sewer Pipe was changed to Clay and Cement-Concrete Pipe.

The latter committee has formally requested that it be divided into two standing committees, one dealing with clay pipe and the other with concrete pipe, and this request is being considered by the Executive Committee with due regard to all its various aspects. In this same connection are being considered requests from the American Society for Municipal Improvements and the American Concrete Pipe Association that the Society undertake the preparation of specifications for reinforced-concrete sewer pipe.

The Executive Committee has, upon request from Committee C-7 on Lime, granted permission to the committee to prepare specifications for lime for the chemical industry, defining simply a standard lime content without specifying rejection limits. Committee C-7 presented a brief urging the acceptance of this type of specification by the Society, giving among other reasons (1) that the use of lime in the chemical industry is such that the material furnished is effective in so far as it is lime; (2) that the use of a material of lower lime content is principally a matter of economic considerations; (3) that no hazard is involved in the use of a lower grade material; and (4) that such a specification, even without rejection limits, is desirable in that it sets up an equitable basis of settlement and will tend gradually to bring all production up to the standard requirement. In approving the request the Executive Committee stipulated that such specifications shall be accompanied by a suitable explanatory note.

The Executive Committee has taken under consideration a suggestion that there be formed a separate standing committee of the Society to prepare specifications for corrosion-resistant alloys.

Committee Procedure.—A number of modifications, some of major importance and others of lesser importance, have been made in committee procedure as set forth in the Regulations Governing Standing Committees. As required, these have been acted upon jointly by the Executive Committee and Committee E-5 on Standing Committees and are given in detail in the report of the latter committee to the Society. The more important modifications are: The classification of the membership of standing committees into producers, consumers and general interests; the requiring of a two-thirds instead of a majority vote of those voting at meetings and on letter ballot of committees on all matters relating to standards and in adoption of committee reports; the requirement that committees shall include in their reports appropriate data respecting new standards and revisions of existing standards; and the publication of certain rulings respecting standards involving patents, referred to in detail elsewhere in this report. The revised Regulations are being presented to the Society by Committee E-5, and by ruling of the Executive Committee will become effective July 1, 1927.

Two other important features of committee procedure are still under consideration: (1) the procedure in a sub-committee charged with the development of complete standards and particularly the methods of voting in connection therewith; and (2) the matter of handling recommendations affecting standards that have been determined upon at committee meetings held during the annual meeting and have therefore not received the required letter ballot vote of the committee prior to the annual meeting. The Executive Committee has requested Committee E-5 to study these questions in detail.

A question has arisen in one of the standing committees respecting an interpretation of the following requirement in Section 2 (*c*) of the Regulations Governing Standing Committees applying to the voting of committee members on letter ballot when a division is demanded:

> "In case two or more members of a committee are connected with the same firm, company, corporation, laboratory, or other institution, they shall, when a division is demanded, jointly command only a single vote."

The Executive Committee has ruled that on any letter ballot of a committee, where the result of the vote would be affected by the application of this rule, it shall be considered that "a division is demanded" and that hence the rule shall apply.

Committee B-2 on Non-Ferrous Metals and Alloys has presented to the Executive Committee a discussion of sub-committee procedure, which while relating particularly to its own work is in some respects of general application to A.S.T.M. committee procedure in general. Some suggestions have been made for simplifying if possible the procedure of standardization as it applies to the development of specifications for non-ferrous metals and alloys within this committee and these proposals are being studied by the Executive Committee.

During the year one very successful series of group committee meetings was held in Philadelphia, March 15–18, 1927. With twenty-five committees taking part and a total attendance of 425, this was the largest group meeting yet held. The group meeting planned for the fall of 1926 was cancelled, however, because for various reasons many of the committees could not conveniently participate. In fact several of the larger committees in the Society have recently modified their meeting plans by omitting fall meetings and holding in their stead meetings of their advisory or executive committees and of some sub-committees, involving, of course, relatively fewer members; so that it is possible that group committee meetings in the fall on the scale contemplated may not continue to serve the convenience of the committees and their members, which is the principal reason for holding them.

Publications:

The regular publications during 1926 were the Proceedings, Supplement to the triennial Book of A.S.T.M. Standards, and the Year

Book. A comparative statement of the volume of regular publications during the past three years is as follows:

	1924, Pages	1925, Pages	1926, Pages
Proceedings	2306	1416	1895
Book of A.S.T.M. Standards	1219	....	....
Supplement to Book of Standards	....	117	102
Year Book (Membership List)	328	352	374
	3853	1885	2371

The volume of regular Society publications is recorded graphically in Fig. 1.

In addition, the Society published in 1926 the Book of A.S.T.M. Tentative Standards (1100 pp.) which is furnished to members on order at special prices. This brings the total number of pages of bound publications issued since the last annual meeting, but not including preprints and reprints, up to 3471.

Reprints of several committee reports were published for committee use and for sale, the principal ones being the report of Committee D-2 on Petroleum Products and Lubricants, 84 pp. (1200 copies), the report of Committee A-5 on Corrosion of Iron and Steel, 44 pp. (750 copies), the report of Committee A-8 on Magnetic Analysis with certain papers and discussions, 65 pp. (425 copies) and the Symposium on Rosin, 48 pp. (1000 copies). The demand for the 1924 Report of the Joint Committee on Concrete and Reinforced Concrete has continued and has necessitated a second printing of 4750 copies.

1927 Book of Standards.—The new policy of issuing the Book of Standards in two parts goes into effect with the 1927 edition. Part I will cover Metals and Part II Non-Metals and members will be furnished on their membership with either one of these parts in cloth binding together with the supplements thereto issued between the years of publication of the triennial book; members desiring both parts pay the sum of $2 triennially in addition to their dues. From present indications about 2000 members, or nearly one-half of the total membership, will wish to secure both parts of the Book of Standards.

A.S.T.M. Bulletin.—The publication of the A.S.T.M. Bulletin under the new policy inaugurated last year, by which the pages of the Bulletin have been made available to certain classes of advertising, has proceeded quite satisfactorily. The three issues of the Bulletin in 1926 carrying advertising were self-sustaining, the income from advertising being just sufficient to meet the total cost of printing and mailing the Bulletin. This has made it possible to put the Bulletins for 1927 upon the same self-sustaining basis and to issue six numbers instead of four, thus keeping the members in closer touch with Society affairs. The volume of appropriate material for announcement through the Bulletin, including general Society affairs, our multitudinous committee activities, cooperative relations with other organizations, continues to grow. Thus the Bulletins for 1927 are planned to contain a total of 58 pages of text matter compared to 28 pages in 1926, an increase of more than 100 per cent.

The January issue of the Bulletin was devoted to a review of the accomplishments of the Society for 1926 and has met with such a favorable reception that it is planned to issue such a review number annually.

Finances of the Society:

The annual statement of the finances of the Society follows in the report of the auditors for the fiscal year, January 1, 1926, to December 31, 1926.

REPORT OF THE AUDITORS FOR THE FISCAL YEAR JANUARY 1, 1926, TO DECEMBER 31, 1926

JOHN HEINS AND CO.
CERTIFIED PUBLIC ACCOUNTANTS

PHILADELPHIA, January 6, 1927.

AMERICAN SOCIETY FOR TESTING MATERIALS,
MR. C. L. WARWICK, *Secretary-Treasurer,*
Philadelphia, Pa.

Dear Sirs:

We respectfully report that we have made an audit and examination of the books and accounts of your Society for the six months ended December 31, 1926, having previously made a similar audit and report for the preceding six months ended June 10, 1926, and at both audits found the accounts to be correct and to be in their usual excellent condition.

We submit balance sheet as of December 31, 1926, as also a statement of cash receipts and disbursements for the twelve months then ended.

We have verified the transactions set forth in the budget record for the last six months as also for the six months ended June 10, last, as reported in ours of June 18, last, and found the same to be correct.

We have verified by actual inspection and count the securities as scheduled under Investments.

Respectfully submitted,

(Signed) JOHN HEINS AND CO.

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BALANCE SHEET AS OF DECEMBER 31, 1926

Assets

Current Funds		$ 6,810.58	
Investments		33,196.26	
Accounts Receivable:			
For Publications and Advertising	$2,567.90		
Members for 1926 Dues	2,296.00		
Members for Binding	42.00		
		$4,905.90	
Furniture and Fixtures		3,753.09	
			$48,665.83

Liabilities

Publications paid for in advance	$127.80		
Members dues paid in advance	883.21		
Members binding paid in advance	3.00		
Entrance Fees paid in advance	235.00		
		$1,249.01	
Life Membership Fund	$1,805.20		
Reserve for Publications	11,121.16		
Surplus	34,490.46		
		$47,416.82	
			$48,665.83

RECEIPTS AND DISBURSEMENTS

JANUARY 1, 1926, TO DECEMBER 31, 1926

Current Funds, January 1, 1926		$5,041.21

Receipts

Current Dues	$58,490.15	
Past Dues	755.00	
Advance Dues	832.46	
Current Entrance Fees	620.00	
Advance Entrance Fees	235.00	
Total Dues		$60,932.61
Sale of Publications:		
Separate Standards	$6,811.86	
Book of Standards	4,811.02	
Book of Tentative Standards	6,207.57	
Proceedings	4,076.03	
Miscellaneous (including special reprints)	4,572.92	
Total Sale of Publications		26,479.40
Carried forward		$87,412.01

Brought forward	**$87,412.01**	
Binding (Members)	812.36	
Advertising in Bulletin	1,279.00	
Authors' Reprints	125.62	
Sale of Certificates of Membership	45.00	
Interest on deposits and investments	2,673.06	
Accrued interest and premium	616.32	
Excess remittances	83.40	
Investments matured or sold	12,000.00	
Registration and other fees, Annual Meeting	1,003.50	
Seaview Golf Club charges, reimbursed by members	323.15	
Miscellaneous	33.34	
Total Receipts		**$106,406.76**

Disbursements

Publications:			
Year Book	$3,237.84		
Proceedings	21,190.49		
Book of Standards and Supplement	1,315.80		
Book of Tentative Standards	3,875.63		
Preprints	2,919.61		
Bulletins and Circulars to Members	3,033.88		
Separate Standards	2,840.62		
Miscellaneous (including special reprints)	1,845.18		
		$40,259.05	
Salaries		$26,791.55	
General Office Expenses		5,287.49	
Expenses, Standing Committees		1,846.16	
Expenses, Annual Meeting		2,425.76	
Traveling Expenses—Executive, Nominating, Correlation of Research and Promotion of Usefulness Committees		738.87	
Rent and insurance, storage rooms		321.00	
Rent, headquarters		2,400.00	
Headquarters maintenance		198.63	
Furniture and Fixtures		361.64	
Certificates of Membership		21.50	
American Engineering Standards Committee		1,565.21	
U. S. National Committee, International Electrotechnical Commission		100.00	
Annual Tables of Constants and Numerical Data		100.00	
Carried forward			$82,416.86

Brought forward	$82,416.86	
Investments	21,172.66	
Accrued interest and premium	616.32	
Seaview Golf Club (See Receipts)	323.15	
Refund of excess remittances	83.40	
Miscellaneous	25.00	
Total Disbursements		$104,637.39
Balance, Current Funds, December 31, 1926		$6,810.58[a]

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[a] Balance accounted for as follows:

Cash on hand	$6,180.40	
Liberty bonds purchased from current year's receipts	15,000.00	
	$21,180.40	
Less checks drawn but not paid against cost of Proceedings	14,369.82	
		$6,810.58

MISCELLANEOUS FUNDS

In addition to the regular Society funds the Secretary-Treasurer has on hand the following funds, partly invested as shown:

Committee A-1 on Steel	$158.00	
Committee A-5 on Corrosion of Iron and Steel	9,743.00	
Committee C-1 on Cement	752.11	
Committee C-9 on Concrete and Concrete Aggregates	635.42	
Committee C-10 on Hollow Masonry Building Units	214.99	
Committee D-1 on Preservative Coatings	28.47	
Committee D-14 on Screen Wire Cloth	58.20	
Joint Committee on Investigation of Phosphorus and Sulfur in Steel	110.47	
Total Committee Funds		$11,700.66

DUDLEY MEDAL AND MARBURG LECTURE FUND

Contributions	$8,893.28		
Interest on Investments	64.92		
Total Receipts		$8,958.20	
Cost of Collection	$674.76		
Honorarium, 1926 Lecturer	200.00		
Cost of Plate for Certificate and Engrossing	193.25		
Stationery	13.55		
Total Disbursements		$1,081.56	
Balance, December 31, 1926			$7,876.64
Investments		6,427.50	
Cash Balance		1,449.14	
			$7,876.64

INVESTMENTS

SOCIETY FUNDS

$15,400	U. S. Liberty Bonds 4th 4¼'s due 1938	$14,936.58	
1,000	" " " " " " " reserve for Index to Proceedings	1,005.47	
10,000	" " " " " " " reserve for 1927 Book of Standards	10,115.69	
2,000	Pennsylvania R. R. Secured Gold Bonds 5's due 1964 held for Life Membership	2,000.00	
3,000	Pennsylvania R. R. Equipment Bonds 6's due 1933	3,052.56	
2,000	Michigan Central Equipment Bonds 6's due 1932	2,085.96	
			$33,196.26

DUDLEY MEDAL AND MARBURG LECTURE FUND

$6,000	Balt. & Ohio R. R. Refunding Bonds 6's due 1995	$6,427.50

COMMITTEE FUNDS

$9,500 U. S. Liberty Bonds 4th 4¼'s due 1938:

Committee A-5	$9,171.56	
Committee C-1	509.53	
		$9,681.09

FINANCIAL CONDITION AT CLOSE OF FISCAL YEARS 1922–1926, INCLUSIVE

Fiscal Year	Assets					Liabilities		
	Current Funds	Investment	Accounts Receivable	Furniture and Fixtures	Total	Accounts Payable[a]	Reserve for Publications	Surplus and Life Membership Fund
1922	$3 495.03	$20 660.65	$5 242.65	$4 293.09	$33 691.42	$663.25	$3 894.61	$29 133.56
1923	5 139.72	23 660.65	5 202.16	3 598.49	37 601.02	467.99	6 894.61	30 238.42
1924	282.06	19 845.44	6 909.42	3 672.90	30 709.82	4 797.31	495.94	25 416.57
1925	5 041.21	24 023.60	3 946.20	3 808.45	36 819.46	1 036.92	4 368.37	31 414.17
1926	6 810.58	33 196.26	4 905.90	3 753.09	48 665.83	1 249.01	11 121.16	36 295.66

[a] These sums represent dues and publications paid in advance and do not include any unpaid bills except for 1924 a loan of $4,000 from the Girard Trust Co.

The surplus on December 31, 1926, was $36,295.66, including the life membership fund of $1805.20. In addition there is the sum of $11,121.16 set aside as a reserve for publications, of which $10,115.69 is to be applied to the 1927 Book of Standards and the remainder, $1005.47, to the collective Index to Proceedings for 1921 to 1925 inclusive. A comparison of the financial condition of the Society at the close of the past five fiscal years is given at the end of the report.

The report lists the funds held to the account of committees of the Society and gives also the statement of the Dudley Medal and Marburg Lecture Fund. Investments of Society and other funds are listed.

The operations for 1926 resulted in a favorable balance between receipts and disbursements as budgeted of approximately $6000. Of this the Executive Committee has transferred to the 1927 budget the sum of $500 for the collective Index to Proceedings and $1000 towards the expense of resetting worn-out type in the Book of Standards. The sum of $1000, being approximately the amount of entrance fees received in 1926, has been invested as an A.S.T.M. Research Fund; the remainder of the surplus has been invested and added to the permanent reserve.

Inventory of Publications in Stock.—In the foregoing financial statement no account has been taken of the assets of the Society in the form of publications in stock. The inventory on May 15, 1927, may be summarized as follows:

	NUMBER OF COPIES
Proceedings	5080
Index to Proceedings (Vols. I - XII, incl.)	540
(Vols. XIII - XX, ")	705
Reprints of 270 standards	20,000 (approx.)
Special reprints for general sale	6500 (approx.)

Society Headquarters:

The lease upon the quarters now occupied by the Society in the Engineers' Club of Philadelphia expires December 31, 1929. The Executive Committee has begun a study of the headquarters situation, taking into account the probable needs of the Society in the next ten years and the possibility of meeting those needs in the present location.

In order to keep pace with the rapid growth of the editorial and publication work of the Society in the past few years, there has been added to the staff another technically trained assistant, increasing the personnel of the Society staff to twelve.

Proposal for Increased Financial Income:

In its report a year ago the Executive Committee presented a statement of the needs for additional income in order that the Society might be in a stronger financial position and especially that we might better be able to publish the constantly increasing volume of standards and of important data on properties of materials being developed by our standing committees. The rapid growth of standardization activities in many industries, the expansion of committee work, and the constant development of new materials and new tests, are all making demands upon the publication facilities of the Society that are certain to increase with time, and more rapidly than our normal increase in yearly income can take care of. If the Society is to keep pace with these developments and render the fullest and most efficient service to its members and to the industries, it is essential that its activities be placed upon a more secure financial basis.

Two recommendations were made last year and approved by the Society: First, that there be established an entrance fee for membership; and secondly, that contributions be solicited from the industries (both producing and consuming materials) to a fund the income of which would be budgeted for current use, particularly to extend the publication facilities. The entrance fee was made effective in September, 1926, by amendment of the By-laws. A special committee, broadly representative of the industrial fields in which the Society is working, was appointed last fall to study the fund plan and to work out the details of putting it into effect. This study led to the proposal that the desired increased support of our work by industry would be better secured in the form of increased dues of companies, firms, corporations and associations than by contributions that would have to be solicited by the Society. The same objective is accomplished, namely, a sum available annually for the extension of Society activities, and accomplished in a way that will probably be more acceptable to the companies and associations to whom the Society looks for this increased support.

The Executive Committee has decided to propose this modification of the earlier plan and to recommend to the Society that the annual dues of companies, firms, corporations, industrial associations and commercial testing laboratories be increased from $15 to $30, the increase if approved by the Society to become effective at the beginning of the next fiscal year, January 1, 1928. It is not proposed that there shall be any change in the present entrance fees for such members. The proposed dues for the company members have been fixed at $30 with two considerations in mind: first, the relatively greater value of the work of the Society in an industrial and commercial sense to companies, firms, corporations, etc., especially in the development of standard specifications and tests and in the carrying on of many studies that have immediate industrial application; and second, the amount of increased income for which it is desirable to plan. There are at present about 1500 companies, firms, corporations, industrial associations and commercial testing laboratories that hold membership as such in the Society, to which the proposed increase in dues would apply. Making reasonable allowances for the uncertainties of a transition period, it is conservatively estimated that the recommendation made herein will result in increasing the annual income of the Society by $15,000 to $20,000, which will enable the Society to increase its publication facilities and to place its activities on a stronger financial basis.

The Executive Committee believes that this method of increasing the Society's income will commend itself as equitable in that the industrial value of the Society's work to companies and corporations, both directly and indirectly, is so great as to justify the greater financial support, and it counts confidently upon the company members to lend their support to this recommendation. However, the Executive Committee particularly wishes to point out that if the recommended increase in dues is approved by the Society, companies that may not wish to give this increased support to the Society's work may still continue their affiliation with the Society by transferring their membership to an individual in the company. In that sense, the whole proposal is upon a voluntary basis, which has been the desire of the Executive Committee throughout its consideration of this important question.

Proposed Amendments of the By-laws:

In order that the foregoing plan may become effective, an amendment of the By-laws is required, and the Executive Committee therefore proposes the following amendment:

Amend Article VII, Section 1, to read as follows by the insertion of the italicized words and the omission of those in brackets:

"Section 1. The fiscal year shall commence on the first day of January. *The annual dues, payable in advance, shall be as follows: For Members that are companies, firms, corporations, industrial associations or commercial testing laboratories, $30; for all other Members, $15; for Junior Members, $7.50; for Student Members, $3.* [The annual dues shall be $15 for Members, $7.50 for Junior Members and $3 for Student Members, payable in advance.] Honorary Members shall not be subject to dues."

Amend the last sentence of Article VII, Section 3, to read as follows by the insertion of the italicized words and the omission of those in brackets:

"The cost of membership in perpetuity to *companies, firms, corporations, industrial associations and commercial testing laboratories shall be $600; to other organizations, $300.* [corporations, firms, technical or scientific societies, teaching faculties or libraries shall be $300.]"

As required by the By-laws, these proposed amendments were announced to the membership in the notices of the annual meeting, first in the April Bulletin and again in a Circular to Members, on June 7, 1927. The plan itself was first announced in the January Bulletin.

Rulings Respecting Standards Involving Patents:

In recent years several instances of proposed standards of the Society involving patents have come before the Executive Committee for ruling under the following provision of the By-laws:

> "Reports, resolutions and recommendations pertaining to or involving the use, or proposed use, in a standard or tentative standard, of any device or process which forms the subject matter of any existing patent, shall first be submitted to the Executive Committee, and shall be submitted to the Society only with the approval of the Executive Committee."

While it is obvious that each case of this kind must be considered upon its merits, it is desired to record certain policies by which the Executive Committee will be guided in considering questions of this kind that may arise in the future. The following statements of policy have been adopted and have been printed as rulings or interpretations in connection with the Regulations Governing Standing Committees so that they may be readily available to the standing committees and the members of the Society:

Applying to the specifying of patented apparatus in A.S.T.M. Standards:

> "Where a standing committee desires to include in a standard of the Society the use of a patented instrument, appliance or machine for testing, for which the committee has written certain specifications, and where this instrument, appliance or machine is the only one specified in the standard, the Executive Committee will approve its inclusion in the standard, provided the owner of the patent will execute a satisfactory agreement with the Society to license any reputable manufacturer approved by the Executive Committee to manufacture such instruments, appliances or machines for testing in accordance with the specifications of the Society.
>
> "Where the patented instrument, appliance or machine concerned is one of several alternative instruments that may be used in applying the standard of the Society, the other instruments not being patented, the Executive Committee will permit reference to such patented instrument without requiring the execution of an agreement such as above outlined, in the belief that the interests of the user of the standard are fully protected against an undesirable patent monopoly in that he can use other unpatented instruments in accordance with the provisions of the standard."

Applying to standards involving patented materials or patented processes:

> "The Executive Committee will consider upon their respective merits any proposals from the standing committees of the Society that specifications be prepared involving patented materials or patented processes. If such speci-

fications are adopted by the Society, the Society does not undertake to insure any one utilizing such specifications against liability for infringement of any patent or assume any such liability, and such adoption does not constitute a recommendation of any patented or proprietary application that may be involved."

In the case of specifications that cover patented materials, the Executive Committee, after obtaining competent legal advice, has voted that the following note shall be published in connection with such specifications, as mentioned in the report a year ago:

> "By the adoption of this specification the Society does not undertake to insure any one utilizing such specification against liability for infringement of any patent or assume any such liability, and such adoption does not constitute a recommendation of any patented or proprietary application that may be involved."

Failure of Apparatus to Conform to A.S.T.M. Standards:

During the year attention of the Executive Committee was called to the fact that certain testing apparatus not in conformity to A.S.T.M. standards was being advertised and marketed as meeting Society requirements. The Executive Committee, while considering undesirable any plan of certification by the Society or its committees that various apparatus conforms to A.S.T.M. standards, feels that it is nevertheless necessary that the Society should take such steps as may be possible to eliminate this undesirable practice. It accordingly adopted the following recommendations, which were published in the Bulletin and given additional publicity by the committee concerned:

1. That purchasers of testing apparatus secure a guarantee from the dealer that apparatus purchased for use in making tests in accordance with A.S.T.M. Standards or Tentative Standards conforms with the requirements for the apparatus specified in such standards or tentative standards; and
2. That instances of failure of apparatus to conform with A.S.T.M. requirements when the apparatus is advertised or marketed as meeting such requirements, be reported to the Society.

Dudley Medal and Marburg Lecture:

At the annual meeting a year ago we were in the midst of raising the sum required to establish the Dudley Medal and Marburg Lecture. By November these funds were completely raised, as reported in the Bulletin for November, 1926. It was decided that the funds for the Medal and Lecture would be kept as a special account separate from general Society funds, and a statement of the Medal and Lecture Fund is included in the auditors' report. The sum available, after deducting all costs, including that of the first lecture, was $7876.64, of which $6427.50 has been permanently invested. From the remainder, $1449.14, will be paid the cost of the dies and first impression for the Dudley Medal, and the balance will be permanently invested. An appropriate medal has been designed, using the head of Doctor Dudley on the obverse and a suitable symbol and inscription on the reverse.

Rules governing the award of the Dudley Medal and the selection of the Marburg lecturer have been adopted by the Executive Committee and will be published in the Year Book of the Society.

Award of the Dudley Medal for 1927.—Upon the unanimous recommendation of the Committee on Medal Award, consisting of M. E. McDonnell, chairman, William Campbell and A. T. Goldbeck, the Executive Committee has awarded the first Charles B. Dudley Medal to Dr. D. J. McAdam, Jr., Metallurgist, U. S. Naval Engineering Experiment Station, Annapolis, Md., for his paper on "Stress-Strain-Cycle Relationship and Corrosion-Fatigue of Metals" presented at the annual meeting of the Society last year. The formal award of the Medal will be made at the Twenty-fifth-Anniversary Dinner during this meeting.

Edgar Marburg Lecturer for 1927.—Upon the recommendation of the Marburg lecture committee, consisting of W. H. Fulweiler, chairman, T. G. Delbridge and F. E. Schmitt, the Executive Committee has invited Dr. George L. Clark, Professor of Applied Chemical Research and Divisional Director of the Research Laboratory of Applied Chemistry in the Massachusetts Institute of Technology, to deliver the second Edgar Marburg Lecture during the coming annual meeting. Doctor Clark will speak on "X-Rays in Industry," a subject of particular importance and timeliness.

Research in Materials:

A review of the activities reported this year by our committees shows in a striking way the development of research in materials by the Society. The fundamental importance of studies of the properties of materials has received increasing emphasis in recent years and the correlation of this work is progressing steadily under the guidance of Committee E-9 on Research organized primarily for that purpose. The activities of this committee as reviewed in its annual report deserve the careful study of the members.

The extent of this investigative work carried on under the auspices of the Society was shown in the review of Society activities for 1926, published in the January Bulletin. Investigations relating primarily to the determination of properties and tests of materials without immediate regard to the problems of standardization, are being carried on side by side with studies the primary purpose of which is to furnish information that will aid in the formulation of suitable standards. It is not an exaggeration to say that this investigative work underlies in a vital sense all that the Society is striving to do.

These investigations are made possible through the interest and support of our hundreds of members engaged in the committee work of the Society. This support takes the form of contribution of time, material and services, laboratory facilities and often direct financial contributions. It is not out of place to express a word of appreciation of these services that help so materially in furthering the objects for which the Society is organized.

The Executive Committee has for some time wished to see established an A.S.T.M. Research Fund, the income from which might be directed to the support of investigative work. In general our committees must continue to finance specific investigations as they have in the past, securing necessary funds direct from the industries that are interested in the results of particular investigations. However, our investigative work will undoubtedly be strengthened if in the future there is available an income from a Research Fund that can be dispersed under suitable auspices to further research activities. This year it has been possible to make a modest start towards such a Fund by the investment of $1000, approximately the amount of the entrance fees received in 1926. Furthermore, the policy has been adopted of investing annually in this Fund one-half of the entrance fees, which will make a yearly addition to the Fund of about $2500. Under this policy the Fund will steadily grow, and with additions thereto that may be expected from time to time from various sources it will in years to come be a factor of far-reaching importance in the development of our work.

Promoting the Usefulness of the Society's Work:

The Special Committee on Promotion of Usefulness of the Society's Work, under the chairmanship of President Gibboney, has continued consideration of various means by which the usefulness of the work of the Society may be extended. In the reports of the Executive Committee for 1925 and 1926 were given somewhat general reviews of the deliberations of this special committee, which have led to the adoption of certain important policies. These have had to do with such matters as: the expansion of the service of the Bulletin of the Society; increasing the publicity of the work of the Society, particularly between annual meetings; extending the use of the Society's standards in various ways, such as their reference in building codes and in the standards developed by large users of materials; the establishment of closer relations with the technical schools, which in turn led to the creation of the class of Student Member; a general survey of the extent of use of A.S.T.M. standards, which has led to the assembling of information of this kind in card index form so as to give a fairly complete reference file; and the encouragement, where feasible, of the plan of certification or guarantee of quality as an aid especially to the small user of materials. The importance of making the greatest possible use of the Society's standards is being kept before the members by means of articles appearing from time to time in the Bulletin.

Consideration is now being given to the possibility of promoting the usefulness of the Society's specifications by publishing an extended list of the industrial applications of the A.S.T.M. specifications and tests, and the interest of Committee A-1 on Steel has been enlisted in the preparation of information of this character applicable to the steel specifications of the Society.

Consideration is also being given to the possibility of issuing a suitable combined index of the standards and tentative standards with the thought that the distribution of such an index among various users of materials, including especially purchasing agents, might effectively bring to their attention the availability of A.S.T.M. specifications in the purchase of a wide variety of materials.

International Congress for Testing Materials:

In September, 1926, there was held in Zurich an International Conference on Materials that led to a decision to resume international discussions on the testing of materials that were interrupted with the World War in 1914 and the subsequent dissolution of the International Association for Testing Materials with which our Society was affiliated as a body and in which some six hundred of our members also held personal membership. Accordingly the Dutch and Swiss Associations for Testing Materials, acting as joint hosts, have issued invitations for an International Congress for Testing Materials to be held September 12 to 17, 1927, at Amsterdam, Holland. The Executive Committee has accepted on behalf of the Society the invitation extended to the Society and its members to participate in the Congress, having for some time held the view that international cooperation in materials is desirable and should be resumed whenever the European nations are prepared to join hands again in this work.

The Executive Committee appointed a special committee to plan for American participation in the Congress, consisting of T. D. Lynch, chairman, P. H. Bates, T. G. Delbridge, Zay Jeffries, and G. W. Thompson. This committee has arranged for the placing on the Congress program of eighteen papers by members of the Society upon a variety of topics that have been announced for discussion. A number of the authors of these papers, together with other members of the Society, have indicated their expectation of attending the Congress.

The Society will be represented at the Congress by an official delegation. It is believed that discussions will take place at the Congress looking towards the reorganization of the International Association for Testing Materials.

The program of the Congress will be announced to the members when received and the details of Society participation in the Congress will be given in the July Bulletin.

The relation of the possible reorganization of the International Association to the question of international standardization, referred to later in this report, has been considered. While expression of opinion regarding the reorganization of the International Association in advance of deliberations of the Congress is premature, the Executive Committee believes that organized efforts towards international *standardization* in the field of materials should be deferred at the International Congress pending the outcome of the present discussions that are taking place respecting international standardization. This position, it should be pointed out, is not opposed to the organization of an International Association concerned primarily with the study of the properties and tests of engineering materials.

A Standardization Survey:

The standardization movement in this country has grown with great rapidity in the past decade. Many organizations, particularly industrial and trade associations, have in that time taken up this work and a number of the great industries of the country have become interested in one or more of its aspects. This rapid growth has naturally brought with it problems of adjustment and coordination, and was undoubtedly one of the principal factors that brought about the organization of the American Engineering Standards Committee. The standardization activities of the Federal Government have also developed rapidly and have been coordinated through the Federal Specifications Board, the Bureau of Standards and, in a closely allied field, the Division of Simplified Practice.

In January, 1927, there was formed under the chairmanship of Herbert Hoover, Secretary of Commerce, a Committee on Standardization Survey for the purpose of studying the present status of standardization, establishing facts and laying them before the industries of the country so that a program of national standardization may be decided that will receive general industrial support. Upon this committee are serving a number of industrial executives and the presidents of several engineering societies, among them the President of this Society, J. H. Gibboney, who has assured the committee that the Society is in sympathy with the purposes of the survey and will coöperate to the fullest possible extent.

At the request of the committee there was prepared for its information a comprehensive report on A.S.T.M. Work in the Field of Standardization, in which was discussed the organization of the Society for the development of standards, the basic principles governing the work, our cooperative relations, methods of promulgation and use of A.S.T.M. standards and their industrial significance. The report contains information both of a general and specific nature that it may be desirable to bring more directly to the attention of the Society membership, and plans are being considered for printing and distributing the report in the fall. In addition, data are being assembled respecting some six or eight outstanding standardization projects that have been developed by the Society as illustrative of the value of materials standards.

Cooperative Relations with Industrial and Trade Associations:

In the preparation of the report referred to in the preceding paragraph, a study was made of the extent to which industrial and trade associations are participating in the standardization work of the Society. In the past ten or fifteen years there has been a marked increase in the number of industrial and trade associations that have been formed in various industries for the consideration of matters of mutual interest to the members of those industries. These associations are able to speak for their industries to a degree that was not possible in most industries ten years ago. This has had a noticeable effect upon the committee work of the Society in that these associations serve to concentrate the thought of the industries on a given problem, to stimulate investigations on properties of materials in which they are interested, to bring about more readily a consensus of opinion on technical matters, and in general to accelerate standardization along many lines, including that of tests and specifications for materials. As these associations have turned to the study of materials problems, the need for close cooperation between them and the Society has been realized. The associations have been encouraged to become affiliated with the Society and to work out their materials standardization problems in cooperation with other groups through the committees of the Society, upon which they are given representation. An examination of the membership and committee records of the Society has shown that 67 technical, industrial and trade associations hold membership in the Society and that 55 are represented either directly or indirectly upon its committees. In addition to these there are 53 technical, industrial and trade associations that are not members of the Society but which cooperate in its standardization work, being represented either upon its committees, upon joint committees with or upon A.E.S.C. sectional committees for which the Society is sponsor.

These figures are significant as illustrating the extent of the cooperative relations that have been established between the Society and the various industries of the country.

International Standardization:

The November, 1926, Bulletin carried announcement to the members of a proposal that originated in the spring of 1926 at the third International Conference of National Standardizing Bodies, that there be organized an international standardizing association of which the members would be the respective national standardizing bodies (for example, in this country, the American Engineering Standards Committee) and having for its purpose the facilitating of general contacts between these bodies to the end that uniformity among national standards may be promoted, with ultimately the function of approval of international standards. A constitution to cover the activities of the proposed association was formulated and presented to the national standardizing bodies for their consideration. This in turn was referred by the A.E.S.C. to its member bodies, and in a formal communication to the A.E.S.C. dated August 19, 1926, the Executive Committee presented a detailed statement of its views of the proposal. Briefly summarized these views may be expressed as follows:

> "1. The Society favors international engineering standardization where the needs and advantages have been clearly defined and the procedure to be followed is acceptable.
>
> "2. The Society urges the importance of careful and deliberate consideration of the whole proposal on the part of American industry, the A.E.S.C. and its member bodies, and is opposed to hasty and possibly ill-considered action.
>
> "3. The formulation of international engineering standards should be based upon the principles that govern the activities of

the A.E.S.C. (A procedure was suggested for American participation in international engineering standardization.)

"4. The proposed constitution is quite indefinite with respect to the attainment of the fundamentally important purpose of approval of international standards, and American participation in this movement should be subject to agreement on procedure between the A.E.S.C. and its member bodies."

Upon the request of the American representative at a subsequent international conference in London in the fall of 1926, action looking towards the formal organization of the international association was postponed for a year. This delay was requested in order to give opportunity to study the best means for American participation in international standardization, particularly in view of the fact that the International Electrotechnical Commission is engaged in standardization in the electrical field and the American representation on the Commission, through the U. S. National Committee of the I.E.C., bears no organic relation to the American Engineering Standards Committee, through which it was proposed to have American representation in the proposed international standards association. At the London conference above mentioned the statutes and by-laws of the proposed association were revised and the name International Federation of National Standardizing Associations suggested. These revised statutes are now under consideration.

Discussions have taken place during the past several months looking to means whereby the interests of the American Engineering Standards Committee and the U. S. National Committee of the I.E.C. in international technical matters may be suitably consolidated for the purpose of American representation in this proposed international movement. These have taken the form of a proposal to enlarge the scope and personnel of the latter committee, prepared by a special committee of the U. S. National Committee and reviewed by a special joint committee of the A.E.S.C. and the U.S.N.C. The Society has participated directly and actively in these various deliberations and the Executive Committee by formal resolution has declared its sympathy with endeavors to establish international relationship in technical matters and its willingness to cooperate in such efforts within the scope of the Society and as outlined in the communication to the A.E.S.C. mentioned above.

A plan of expanding the U. S. National Committee in such a way as to give equal representation to the founder engineering societies and the American Engineering Standards Committee, with suitable representation also from the Federal Government, has been approved in principle by the Executive Committee as holding possibilities of adequate American representation in the international movement. Recently the U. S. National Committee has proposed important modifications of this plan, which are now under consideration by the Executive Committee.

During the year two proposals for international standardization of materials have been received, one from a member of the Society respecting international standard specifications and tests for turpentine, and the other from Committee A-3 on Cast Iron requesting that means be provided whereby the committee can participate in international standardization of pig iron and cast iron. The Executive Committee has considered it inexpedient to take any formal steps in either of these matters until a better understanding has been reached between this country and other nations respecting the handling of international standardization matters.

U. S. National Committee, International Electrotechnical Commission:

During the year the Society has continued to take an active part in that phase of the work of the International Electrotechnical Commission in which it is particularly interested, namely, tests of insulating oils. One of the Society's representatives on the U. S. National Committee, E. A. Snyder, has prepared a comprehensive report of the status of this subject, which has been referred to the appropriate committees of the Society for their information and comment. The Society has aided in the appointment of a committee of advisers on this subject under the chairmanship of Mr. Snyder.

There are probably other materials than insulating oils that it might be profitable to consider internationally from the point of view of their use in the electrical industry. The Executive Committee has therefore offered the services of the Society and its committees to the U. S. National Committee in the consideration of such materials as the electrical industry wishes to discuss internationally, and the offer has been cordially accepted. At the same time it was felt that the interests of the Society in this work justify increasing the financial contribution by the Society towards the expenses of the U. S. National Committee and this contribution has been increased from $100 to $250 for this year.

There have come up during the year proposals to enlarge the scope of the U. S. National Committee in view of developments in the field of international standardization that are discussed earlier in this report. The U. S. National Committee invited each of its member bodies to appoint a representative upon a special committee charged with the study of this proposed enlargement. Vice-President G. W. Thompson was appointed to represent the Society in this capacity, which led later to his appointment as a second representative of the Society upon the U. S. National Committee itself.

American Engineering Standards Committee:

The important place of the American Engineering Standards Committee in the national standardization movement is becoming more clearly defined as the work of the committee expands and becomes more widely recognized and supported by the various agencies throughout the country concerned with standardization. The function of the Standards Committee as a coordinating agency has become increasingly important to our Society as new standardization projects in the field of engineering materials have been taken up, carrying with them increased responsibilities and a broadening of cooperative relations between the Society and other bodies engaged in standardization. During the year several such projects of major importance have been inaugurated and are briefly described below. Where these projects relate to standardization activities that have been of long standing in the Society there arises the problem of correlating our committee work with the A.E.S.C. sectional committee procedure. In several instances this problem has been met by having A.S.T.M. committees approved as sectional committees under A.E.S.C. procedure, adding, where necessary, representatives of organizations not hitherto connected with the work and arranging wherever possible for members of the committee to be officially designated as representatives of other interested organizations which under A.E.S.C. procedure must be officially represented. Consideration is being given to the possibilities of a wider application of this plan as applying to other committees and, in some cases, sub-committees.

The Executive Committee has decided that it shall not be contrary to the policy of the Society to offer to the A.E.S.C. for approval as Tentative American Standard any proposed standards prepared under sectional committee procedure for which the Society is sponsor or co-sponsor, which have been accepted as A.S.T.M. Tentative Standards. This procedure is designed to facilitate the submission of standards to the A.E.S.C. for approval.

The position of the A.E.S.C. in the international standardization movement has been under consideration for some time and is referred to earlier in this report.

The Society is sponsor or joint sponsor for a number of projects that have been assigned to sectional committees, which are listed in the current Year Book. It is also represented upon a number of sectional committees sponsored by other organizations, which are also listed in the Year Book. In the following paragraphs are given brief comments upon the principal developments that have taken place during the year in A.E.S.C. projects with which the Society is connected.

In the report a year ago the organization of three sectional committees was announced. The Sectional Committee on Specifications for Zinc Coating of Iron and Steel has made substantial progress in the problems that have been assigned to it and a report of progress is being presented at this meeting. Close cooperative relations have been established between this sectional committee and Committee A-5 on Corrosion of Iron and Steel; thus the sub-committees on Methods of Testing of the two committees are identical in personnel. Similarly, the Sectional Committee on Specifications for Cast Iron Pipe has been effectively organized and is reporting progress to its sponsor bodies. This report is on the program of the present annual meeting. The Sectional Committee on Hard-Drawn and Medium-Hard-Drawn Copper Wire, the personnel of which is coincident with that of Committee B-1 on Copper Wire, has been expanded in scope to include soft wire and it is proposed also to include within its scope the subject of specifications for tinned wire. Revisions of the Society's specifications covering these various products are being reviewed by the Sectional Committee.

Three other sectional committees, organized for some time, have been active during the year. The report of the Sectional Committee on Fire Tests recommending revised specifications for fire tests of materials and construction, presented at the annual meeting a year ago, has been referred to the A.E.S.C. and the revised specifications approved as Tentative American Standard. The sectional committee is not yet prepared to recommend advancement to American Standard. The Sectional Committee on Methods of Testing Wood is recommending this year that the Tentative Methods of Testing Small Clear Specimens of Timber (D 143 - 24 T) and the Tentative Methods for Conducting Static Tests of Timbers in Structural Sizes (D 198 - 24 T) be offered to the A.E.S.C. for approval as American Standard. These methods of test have been published as tentative by the Society for several years and are being recommended by Committee D-7 simultaneously for advancement to A.S.T.M. standard. The Sectional Committee on Numbering of Steels has been reviewing the project assigned to it from the point of view of its practicability and expediency. The discussions within the committee have appeared to indicate that there is no prospect of arriving at a practical solution of the problem. A formal report of the sectional committee is being awaited.

During the year three new sectional committees have been organized, as follows:

Sectional Committee on Specifications for Cement.—On September 28, 1926, the Sectional Committee on Specifications for Cement was formed for the purpose of passing upon revisions of the American Standard Specifications and Tests for Portland Cement, approved by the A.E.S.C. as American Standard on March 31, 1922. The sectional committee consists of 22 members, appointed by nine organizations, including the Society, and three liaison representatives from the Federal Specifications Board. The complete personnel of the committee is published in the 1926 Year Book of the Society. Under date of February 10, 1927, the sectional committee presented a report recommending that the revised Standard Specifications and Tests for Portland Cement adopted as a standard of the Society last year, be approved by the A.E.S.C. as American Standard. This recommendation was approved by a vote of 18 affirmative, 3 negative and 1 not voting, with the three liaison government representatives unofficially approving. Action by the Society having already been taken upon the adoption of the specifications themselves, the Executive Committee has formally approved the report of the sectional committee and transmitted it to the A.E.S.C. for its consideration.

Sectional Committee on Specifications for Rubber-Lined Fire Hose.—On November 5, 1926, there was organized under the joint sponsorship of the A.E.S.C. Fire Protection Group and this Society, the Sectional Committee on Specifications for Rubber-Lined Fire Hose to which was assigned the problem of developing standards of construction and performance under test of rubber-lined fire hose for use by private and public fire departments. It is desired to harmonize the requirements of various specifications for this product that are in use to-day. The committee consists of 14 members appointed by nine organizations, the representatives of the Society being H. L. Miner and W. L. Sturtevant. The committee has held several meetings at which successive drafts of specifications have been drawn up and discussed. Substantial progress has been made but the committee is not yet prepared to report to its sponsor bodies.

Sectional Committee on Methods of Testing Petroleum Products and Lubricants.—Sponsorship for this project was assigned to the Society in consideration of the fact that we have been engaged for a number of years in the development of tests for petroleum products and lubricants. Accordingly the personnel of Committee D-2 on Petroleum

Products and Lubricants, with certain additions, has been submitted to and approved by the A.E.S.C. as the sectional committee on this subject, so that the two committees will function coincidentally. The committee is thoroughly representative of all interests concerned in the testing of petroleum products and, at the time of its organization as a sectional committee, contained 103 members, classified into 48 producers, 37 consumers, 17 general interests and 1 liaison member. The committee has now under review a considerable number of the A.S.T.M. standard and tentative methods of test for petroleum products, for the purpose of their submission to the A.E.S.C. for approval.

The organization of a Sectional Committee on Methods of Test of Road Materials, for which the Society is sponsor, is nearly completed. As in other instances the effort is being made to have the personnel of Committee D-4 on Road and Paving Materials, with the addition of designated representatives of certain organizations not heretofore represented, approved as the sectional committee to develop tests for road materials.

The Executive Committee has accepted sponsorship for the Society under A.E.S.C. procedure for the development of a plan for the Classification of Coals, which is to include all coals from anthracite to lignite and to be based upon such chemical and physical characteristics as will make the plan most readily adaptable to industrial and commercial use on a national scale. The formation of the sectional committee to handle this project is under way, invitations having been extended to about twenty organizations to be represented in this work. This project is perhaps one of the most important of its kind from a commercial and industrial standpoint the Society has yet undertaken, and it will require the whole-hearted support of the coal-producing and coal-using industries to establish a system of classification that will find national acceptance. The effort will be made to include Canadian and perhaps Mexican coals and it is hoped that eventually a world classification can be developed.

The Executive Committee has under consideration an invitation to act as joint sponsor with the American Society of Mechanical Engineers for the development of national standards for wrought-iron and steel pipe and tubing. The project is being discussed with Committees A-1 on Steel and A-2 on Wrought Iron.

Of the projects for which the Society is not sponsor but upon which we are represented, only the following require particular mention. The Sectional Committee on Insulated Wires and Cables has formally approved the two A.S.T.M. Standard Specifications for Soft or Annealed Copper Wire (B 3 – 15) and for Tinned Soft or Annealed

Copper Wire for Rubber Insulation (B 33 - 21) for inclusion in genera wire and cable specifications. The Sectional Committee on Gears has been engaged in the development of specifications for forged and rolled carbon steel for gears, in which the Society through its representatives on the committee has taken an active part. Similarly, through Committee A-1 on Steel, the Society is in active touch with the work of the Sectional Committee on Pipe Flanges and Fittings, having developed four specifications for materials for reference in the general standards being formulated by the sectional committee.

The Society has participated actively in the work of the Sectional Committee on Engineering Symbols and Abbreviations, the Assistant Secretary of the Society having served as secretary of the Sub-Committee, of this sectional committee, on Mechanics, Structural Engineering and Testing Materials. It is expected that definite recommendations will be submitted during the coming year for a list of standard symbols applicable in testing work.

The Society has had the opportunity of cooperating in the preparation of recommendations covering the form of standards through the service on a Special A.E.S.C. Committee on Form and Arrangement of Published Standards and Specifications, of its representative, F. M. Farmer, with the Assistant Secretary serving as alternate.

Use of Specifications in Foreign Trade:

The development of more systematic means of promoting the use of American standard specifications in foreign trade has been under consideration in various ways, principally through discussions that have taken place in the American Engineering Standards Committee. The Society has had a very definite interest in this subject since 1916, when arrangements were made with the Department of Commerce to translate a number of A.S.T.M. specifications covering materials entering largely into export trade, into Spanish, French and, more recently, Portuguese. This work of translation and the extension of the use of specifications in foreign trade is centered in the Bureau of Foreign and Domestic Commerce of the U. S. Department of Commerce. It is believed that this work should continue to be carried forward by the Bureau and that the industries, associations and technical societies interested should render every possible assistance in order to develop a more systematically organized plan of promoting foreign language editions of standards. It is planned to form through the A.E.S.C. a representative committee advisory to the Bureau of Foreign and Domestic Commerce for this work.

During the past year the Department of Commerce has continued the revision of the original Spanish translation of a number of A.S.T.M. specifications to bring them up to date. In addition to those mentioned a year ago, thirteen specifications have been revised covering certain structural material, forging material, boiler plate and rivet material, wrought-iron bars, steel castings and railway track and equipment material.

Division of Simplified Practice, U. S. Department of Commerce:

The Society has continued to keep in touch with those simplification projects of the Division of Simplified Practice that relate in any way to A.S.T.M. activities. Those that have come up during the year that fall in this category are the following: (1) recommended sizes of numbered cotton duck, which have been approved by Committee D-13 on Textile Materials; (2) recommended sizes of wrought-iron and steel pipe, which have been approved by Committees A-1 on Steel and A-2 on Wrought Iron and embodied in proposed revisions of the Society's specifications covering these products; and (3) recommended sizes of paving brick, which have recently been referred to Committee C-3 on Brick for consideration.

National Committee on Metals Utilization:

During the year a National Committee on Metals Utilization, composed of representatives of professional societies, trade associations and others interested primarily in the metals using industries, has been formed under the chairmanship of the Secretary of Commerce, to direct the campaign to eliminate waste in these industries, thus taking over in effect the work in the metals using industries begun several years ago in the Division of Simplified Practice. The Executive Committee has accepted an invitation for the Society to be represented on this committee, designating the Secretary-Treasurer as a member.

The principal activity of the Committee of direct interest to the Society has been the agreement of a general conference of representatives of manufacturers, distributors and users, to concentrate upon one grade of billet-steel concrete reinforcement bars for standard production, namely, the intermediate grade as specified in the A.S.T.M. Standard Specifications for Billet-Steel Concrete Reinforcement Bars (A 15 – 14). The representatives of the Society at this conference took the position that so long as there is a demand in the trade for the other grades of billet-steel reinforcement bars, specifications for these grades should remain in the Society standard. A request of the National Committee that the Society take under advisement the question of suitable modifications of the existing specifications has been referred to Committee A-1 on Steel for its consideration.

The National Committee has appointed a special committee to follow the operations of this recommendation, upon which the Society will be represented.

Division of Engineering, National Research Council:

Through its representation the Society continues to maintain contacts with the Division of Engineering and Industrial Research and its various committees, especially the Advisory Board on Highway Research, the Bureau of Welding and the Committee on Corrosion. During the year a Research Committee on Structural Steel Welding has been organized under the auspices of the Division and upon invitation to be represented the Executive Committee has designated F. M. Farmer to serve upon this committee.

American Association for the Advancement of Science:

The Society formally participated in the annual meeting of the American Association for the Advancement of Science in December, 1926, by arranging for the presentation of a paper at the meeting of the Association's Section on Engineering. The paper was written and presented by Past-President W. H. Fulweiler, who discussed "The Relationship Between Science and the Study and Testing of Engineering Materials."

Army Ordnance Association Meeting:

The Executive Committee has accepted for the Society a cordial invitation extended by the Army Ordnance Association for the members of the Society to be its guests during its annual meeting at Aberdeen, Md., on Thursday, October 6. The annual meeting of the Association is the occasion for a complete demonstration of army ordnance in the interest of the National Defense Program and will be not only interesting but distinctly worth while to all who can arrange to attend. Moreover, the standardization work of the Society is in many of its phases of much interest to the Ordnance Department of the Government and the establishment of contacts made possible through this meeting will be mutually helpful. Details of the meeting will appear in the July Bulletin and each member will receive an official invitation from the Army Ordnance Association.

Miscellaneous Cooperative Work:

The Society is represented upon a number of joint committees, as set forth in detail in the Year Book of the Society. Among those that have been more particularly active during this year are the following. The Joint Committee on Definitions of Terms Relating to Heat Treatment has presented a report containing a series of recommended definitions that have been referred to Committee A-4 on Heat Treatment of Iron and Steel and are being reported to the Society in the annual report of that committee. Joint committees with the American Electric Railway Association dealing with girder rails and trolley wire have been at work, as recorded in the reports of Committees A-1 on Steel and B-1 on Copper Wire, respectively. A cooperative study with the American Railway Association on inclusions in steel forgings is being arranged through Committee A-1 on Steel. The Society is represented in a joint research committee of the American Society of Mechanical Engineers and the American Welding Society on welded pressure vessels. The Joint Research Committee on Effect of Temperature on the Properties of Metals is presenting a progress report to its sponsor societies, the A.S.M.E. and the A.S.T.M., and is making very satisfactory progress in the investigations that it has under way. The Joint Committee on Investigation of the Effect of Phosphorus and Sulfur in Steel has continued its activities during the year and is presenting a report of progress at this annual meeting. The Society has kept in touch with the soil corrosion investigations of the Bureau of Standards through representation upon two advisory committees. Arrangements have been made for cooperative work with the American Concrete Institute on definitions of terms relating to concrete, the details being handled by Committee E-8 on Nomenclature and Definitions. A joint committee with the National Electrical Manufacturers Association is discussing methods of testing molded insulation, the Society's representatives having been appointed from Committee D-9 on Electrical Insulating Materials.

Important cooperative contacts have been established between Committee D-2 on Petroleum Products and Lubricants and the Interdepartmental Committee on Lubricating and Liquid Fuels in the development of methods of testing petroleum products for use in Federal specifications. The Society of Automotive Engineers is participating actively in certain phases of the rubber testing work of Committee D-11 on Rubber Products. Cooperation with the American Railway Engineering Association has been continued through Committee D-7 on Timber in the development of grading rules for structural timber, which are being reported by that committee this year for adoption as standard.

The Bureau of Standards, in cooperation with the American

Wood Preservers' Association and Committee D-7 of this Society, is undertaking the determination of density and thermal expansion constants of creosote oil, for which there is great need on the part of both producers and users of this product.

The Society has cooperated with the American Marine Standards Committee during the year in the consideration of specifications for marine boiler plate, details of which were handled by Committee A-1 on Steel, and in the discussion of proposed specifications of the A.M.S.C. for refractories, which were reviewed and criticized by Committee C-8 on Refractories.

Recently the National Safety Council has formed a special committee to undertake an exhaustive study of the effect of annealing of chains from the point of view of safety, and the Society has accepted an invitation to be represented in this work.

The Society has continued its cooperation with the Boiler Code Committee of the American Society of Mechanical Engineers through a special joint committee that considers questions relating to materials specifications in the Boiler Code. In this way the latest modifications of A.S.T.M. specifications are brought promptly before the Code Committee and questions of interpretation or suggestions for modifications originating in that Committee may be readily brought to the attention of the proper committee of the Society.

Museums of the Peaceful Arts:

There has recently been formed an Association for the Establishment and Maintenance for the People in the City of New York of Museums of the Peaceful Arts made possible through the beneficence of the late Henry R. Towne. The Museum is to contain exhibits of industrial machinery, of science and the arts, from the days of primeval man to the present. The cooperation of the various national technical societies has been invited and the Executive Committee has appointed Past-President F. M. Farmer and the Secretary-Treasurer to act in an advisory capacity. The purposes of industrial museums of this kind are highly commendable and it is possible that the Society may be of assistance in securing suitable exhibits of testing apparatus and testing machinery of various kinds.

Respectfully submitted on behalf of the Executive Committee,

J. H. GIBBONEY,
President.

C. L. WARWICK,
Secretary-Treasurer.

REPORT OF COMMITTEE A-1
ON
STEEL

During the year Committee A-1 has held two meetings, one on January 14, the second on March 18, 1927. A meeting will be held prior to the presentation of this report to the Society, at which the report will be reviewed and other matters considered.

The Advisory Committee has held three meetings, at which general administrative matters were considered.

The present membership of the committee is 171 of which 89 are classed as non-producers and 82 as producers.

RECOMMENDATIONS AFFECTING STANDARDS AND TENTATIVE STANDARDS

The recommendation of the committee affecting standards and tentative standards are presented first in summarized form together with an analysis of the letter ballot vote on each item. They are then referred to where necessary, in greater detail, being grouped for convenience in the order of the sub-committees directly responsible for them.

I. Proposed Revisions in Standards.—The committee recommends that the revisions in the following standards be referred to letter ballot of the Society for adoption as standard.[1] These revisions are divided into two groups:

A.—Revisions proposed at the 1925 and 1926 annual meetings and now recommended for adoption by letter ballot.

B.—Revisions now proposed for the first time, as indicated in items Nos. 1 to 4 in Appendix III, which the committee recommends be referred to letter ballot of the Society by the necessary nine-tenths vote of the annual meeting.

The standard specifications in each group are as follows:

GROUP A

Revisions Presented in 1925[2] and 1926[3] and Recommended for Adoption:

(Unless otherwise specified the revisions are recommended for adoption without amendment.)

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[1] Except as noted under Item No. 1 in Appendix III where two revisions proposed in 1926 are recommended to be continued as tentative, or possibly eliminated.

[2] *Proceedings*, Am. Soc. Testing Mats., Vol. 25, Part I, pp. 75 ff. (1925).

[3] *Proceedings*, Am. Soc. Testing Mats., Vol. 26, Part I, pp. 106 ff. (1926).

For Silico-Manganese-Steel Bars for Automobile and Railway Springs (A 59 - 16);
For Carbon-Steel and Alloy-Steel Forgings (A 18 - 21);
For Quenched-and-Tempered Carbon-Steel Axles, Shafts and Other Forgings for Locomotives and Cars (A 19 - 21);
For Carbon-Steel Forgings for Locomotives (A 20 - 21);
(An additional revision is being recommended as indicated in Appendix III, requiring a nine-tenths vote for adoption. Other revisions are being recommended for adoption without modification.)
For Carbon-Steel Bars for Vehicle and Automobile Springs (A 58 - 16);
For Carbon-Steel Bars for Railway Springs (A 14 - 16);
For Chrome-Vanadium-Steel Bars for Automobile and Railway Springs (A 60 - 16);
For Quenched-and-Tempered Alloy-Steel Axles, Shafts and Other Forgings for Locomotives and Cars (A 63 - 21);
For Carbon-Steel Bars for Railway Springs with Special Silicon Requirements (A 68 - 18);
For Boiler and Firebox Steel for Stationary Service (A 70 - 24);
For Lap-Welded and Seamless Steel and Lap-Welded Iron Boiler Tubes (A 83 - 24);
For Welded and Seamless Steel Pipe (A 53 - 24).
(Modifications of the revisions of several sections presented in 1926 are recommended as well as new revisions presented for the first time as indicated in Appendix III, the latter requiring a nine-tenths vote for adoption. Other revisions are being recommended for adoption without modification.)

GROUP B

Revisions Proposed for First Time and Recommended for Adoption:

For Automotive Carbon and Alloy Steels (A 29 - 24);
For Alloy Steel Bolting Material for High Temperature Service, (A 96 - 26).

II. Tentative Specifications Advanced to Standard.—

(*a*) The committee recommends that the following tentative specifications be advanced to standard without revision:

For the Manufacture of Open-Hearth Steel Girder Rails of Plain, Grooved and Guard Types (A 2 - 26 T);[1]
For Structural Silicon Steel (A 94 - 25 T).[2]

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 26, Part I, p. 626 (1926); also 1926 Book of A.S.T.M. Tentative Standards, p. 22.

[2] *Proceedings*, Am. Soc. Testing Mats., Vol. 25, Part I, p. 514 (1925); also 1926 Book of A.S.T.M. Tentative Standards, p. 62.

(*b*) The committee recommends that the revisions in the following tentative specifications be approved, as given in Appendix II to this report, and that the specifications as amended be advanced to standard:

For Open-Hearth Carbon-Steel Rails (A 1 - 26 T);
For Carbon-Steel Car and Tender Axles (A 21 - 25 T);
For Low-Carbon Steel Track Bolts (A 76 - 20 T);
For Cold-Drawn Steel Wire for Concrete Reinforcement (A 82 - 21 T);
For Carbon-Steel Castings for Railroads (A 87 - 22 T);
For Commercial Quality Hot-Rolled Bar Steels (A 107 - 26 T);
For Commercial Cold-Finished Bar Steels and Cold-Finished Shafting (A 108 - 26 T);
For Steel Plates of Structural Quality for Forge Welding (A 78 - 23 T);
For Steel Plates of Flange Quality for Forge Welding (A 89 - 23 T).

III. Proposed Revisions in Tentative Standards.—The committee recommends that the revisions in the following tentative specifications be approved as given in Appendix III to this report, and that the specifications, as amended, be continued as tentative:

For Carbon-Steel Castings for Valves, Flanges and Fittings for High-Temperature Service (A 95 - 26 T);[1]
For Forged or Rolled Steel Pipe Flanges for High-Temperature Service (A 105 - 26 T);
For Lap-Welded and Seamless Steel Pipe for High-Temperature Service (A 106 - 26 T);
For Cold-Rolled Strip Steel (A 109 - 26 T).

IV. Proposed New Tentative Standards.—The committee recommends that the following new tentative standards, appended to this report,[2] be accepted for publication as tentative:

Specifications for Structural Steel for Locomotives and Cars;
Specifications for Marine Boiler Steel Plates;
Specifications for Alloy Tool Steel.

V. Tentative Standards.—The committee recommends that the following tentative specifications be continued as tentative for another year without revision:

For Soft Steel Track Spikes (A 65 - 26 T);
For Steel Tie Plates (A 67 - 20 T);

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[1] The proposed revisions of these specifications were not accepted at the annual meeting but were referred back to Committee A-1 for further consideration.—ED.

[2] See pp. 651, 658 and 676.—ED.

For Electric Cast-Steel Anchor Chain (A 77 - 20 T).

(Specification A 77 - 20 T will be revised and brought into line with current practice during the coming year.)

The above recommendations have been referred to letter ballot vote of the committee, which consists of 171 members; 148 ballots have been cast; 23 members having failed to return their ballots. The analysis of the vote of the committee is given in the following table:

Items	Affirmative	Negative	Not Voting[a]
I. TENTATIVE REVISIONS OF STANDARDS ADVANCED TO STANDARD			
For Silico-Manganese-Steel Bars for Automobile and Railway Springs (A 59 - 16)	81	0	67
For Carbon-Steel and Alloy-Steel Forgings (A 18 - 21)	103	0	45
For Quenched-and-Tempered Carbon-Steel Axles, Shafts and Other Forgings for Locomotives and Cars (A 19 - 21)	87	0	61
For Carbon-Steel Bars for Vehicle and Automobile Springs (A 58 - 16)	79	0	69
For Carbon-Steel Bars for Railway Springs (A 14 - 16)	86	0	62
For Chrome-Vanadium-Steel Bars for Automobile and Railway Springs (A 60 - 16)	79	0	69
For Quenched-and-Tempered Alloy-Steel Axles, Shafts and Other Forgings for Locomotives and Cars (A 63 - 21)	85	0	63
For Carbon-Steel Bars for Railway Springs with Special Silicon Requirements (A 68 - 18)	82	0	66
For Boiler and Firebox Steel for Stationary Service (A 70 - 24)	88	1	59
For Lap-Welded and Seamless Steel and Lap-Welded Iron Boiler Tubes (A 83 - 24)	92	0	56
II. PROPOSED REVISIONS OF STANDARDS			
1. For Welded and Seamless Steel Pipe (A 53 - 24)	84	1	63
2. For Alloy-Steel Bolting Material for High-Temperature Service (A 96 - 26)	77	0	71
3. For Carbon-Steel Forgings for Locomotives (A 20 - 21)	83	0	65
4. For Automotive Carbon and Alloy Steels (A 29 - 24)	74	1	73
III. TENTATIVE SPECIFICATIONS ADVANCED TO STANDARD			
5. For Open-Hearth Carbon-Steel Rails (A 1 - 26 T), as revised	68	0	80
6. For the Manufacture of Open-Hearth Steel Girder Rails of Plain, Grooved and Guard Types (A 2 - 26 T)	63	1	84
7. For Low-Carbon-Steel Track Bolts (A 76 - 20 T), as revised	70	0	78
8. For Cold-Drawn Steel Wire for Concrete Reinforcement (A 82 - 21 T) as revised	71	0	77
9. For Carbon-Steel Car and Tender Axles (A 21 - 25 T), as revised	75	0	73
10. For Steel Plates of Structural Quality for Forge Welding (A 78 - 23 T), as revised	82	2	64
11. For Steel Plates of Flange Quality for Forge Welding (A 89 - 23 T), as revised	81	2	65
12. For Carbon-Steel Castings for Railroads (A 87 - 22 T), as revised	76	4	68
13. For Commercial Quality Hot-Rolled Bar Steels (A 107 - 26 T), as revised	90	1	57
14. For Commercial Cold-Finished Bar Steels and Cold-Finished Shafting (A 108-26 T), as revised	80	1	67
15. For Structural Silicon Steel (A 94 - 25 T)	79	0	69
IV. PROPOSED REVISIONS OF TENTATIVE STANDARDS			
16. For Carbon-Steel Castings for Valves, Flanges, and Fittings for High-Temperature Service (A 95 - 26 T)	58	23	67
17. For Forged or Rolled Steel Pipe Flanges for High-Temperature Service (A 105-26 T)	79	0	69
18. For Lap-Welded and Seamless Steel Pipe for High-Temperature Service (A 106-26 T)	80	3	65
19. For Cold-Rolled Strip Steel (A 109 - 26 T)	75	1	72
V. PROPOSED NEW TENTATIVE STANDARDS			
20. For Structural Steel for Locomotives and Cars	85	4	59
21. For Marine Boiler Steel Plates	77	0	71
22. For Alloy Tool Steel	77	1	70

[a] In this column are recorded the number of votes cast as "Not Voting" on the various items.

Total number of ballots cast	148
Number of members who failed to vote	23
Total membership	171

The committee formally passed the following resolutions approving: (*a*) A simplification of pipe sizes; (*b*) a request from Sub-Committee I, for cooperation with the American Railway Engineering

Association; and (*c*) a request from Sub-Committee VI for cooperation with the American Railway Association, as follows:

(*a*) RESOLVED, That Committee A-1 approves the simplification of pipe sizes adopted by a general conference held by the Department of Commerce on May 28, 1926, at Washington, D. C., eliminating from the list of standard sizes, 4½, 7, 9 and 11-in. pipe. The committee however suggests the use of the terms "welded and seamless steel pipe" as being more definite than "wrought steel pipe," the term employed by the General Conference.

(*b*) RESOLVED, That Committee A-1 advise the Executive Committee of the Society that Committee A-1 would welcome an opportunity to cooperate with the American Railway Engineering Association in the investigation of the origin of shattering cracks in steel rails.

(*c*) RESOLVED, that the Society, through the proper channels, advise the American Railway Association that it is in sympathy with the investigation of inclusions in forgings, particularly slag inclusions and will welcome information as to what cooperation the Association might desire.

In the following the committee presents the recommendations as to standards and tentative standards in detail where necessary, as well as other features of its work, grouped for convenience in the order of the respective sub-committees responsible for them.

SUB-COMMITTEE I ON STEEL RAILS AND ACCESSORIES

This sub-committee has kept in close touch with the interested committees of the American Railway Engineering Association and the American Electric Railway Engineering Association, and the revisions presented in Appendix II are the result of this cooperation. The Specifications for Carbon Steel Rails (A 1 – 26 T), revised as indicated, and for Open-Hearth Girder Rails (A 2 – 26 T) are now in entire agreement with the specifications of these two associations.

SUB-COMMITTEE II ON STRUCTURAL STEEL FOR BRIDGES, BUILDINGS AND ROLLING STOCK

This sub-committee has prepared a revision and combination of the Specifications for Structural Steel for Locomotives (A 10 – 24) and Structural Steel for Cars (A 11 – 24). The consolidated specifications are appended hereto and are presented as a new tentative standard.

SUB-COMMITTEE III ON STRUCTURAL STEEL FOR SHIPS

Sub-Committee III has continued the cooperative work commenced two years ago with the U. S. Navy, U. S. Steamboat Inspection Service, Classification Societies, American Marine Standards Committee and the Manufacturers, in the preparation of Specifications for Marine Boiler Steel Plates. The specifications appended hereto are presented for publication as tentative.

SUB-COMMITTEE V ON STEEL REINFORCEMENT BARS

Sub-Committee V is presenting a revision in the Tentative Specifications for Cold-Drawn Steel Wire for Concrete Reinforcement (A 82 - 21 T), increasing the maximum size of wire covered by the specifications to meet the demands of the trade.

SUB-COMMITTEE VI ON STEEL FORGINGS AND BILLETS

Sub-Committee VI is recommending a revision in the Tentative Specifications for Carbon-Steel Car and Tender Axles (A 21 - 25 T) to provide for the annealing of axles over $6\frac{1}{2}$ in. in diameter at the center, which is considered desirable by users and manufacturers as well.

SUB-COMMITTEE VIII ON STEEL CASTINGS

This sub-committee is recommending a slight revision in the Tentative Specifications for Carbon-Steel Castings for Railroads (A 87 - 22 T).

A sub-sub-committee under the chairmanship of Mr. J. A. Capp has completed a valuable investigation on the size and location of test coupons. The report of this sub-sub-committee is given in full in Appendix I as adopted by Sub-Committee VIII.

SUB-COMMITTEE XIV ON TOOL STEEL

This sub-committee has prepared new Specifications for Alloy Tool Steel which are appended hereto and are presented for publication as tentative.

SUB-COMMITTEE XV ON COMMERCIAL BAR STEELS

Sub-Committee XV is recommending revisions in the Tentative Specifications for Commercial Quality Hot-Rolled Bar Steels (A 107 - 26 T) and for Commercial Cold-Finished Bar Steels and Cold-Finished Shafting (A 108 - 26 T). The revisions include a new schedule of size tolerances and the inclusion of commercial key stock in the material covered by Specifications A 108 - 26 T. An increase in the upper limit for manganese from 0.80 to 0.90 per cent in bessemer screw stock is recommended in both specifications. It is believed that this change reflects the present trend and will be generally acceptable.

SUB-COMMITTEE XXI ON STEEL FOR WELDING

This sub-committee is recommending that the Tentative Specifications for Steel Plates of Structural Quality for Forge Welding (A 78 – 23 T) and for Steel Plates of Flange Quality for Forge Welding (A 89 – 23 T) be advanced to standard amended as indicated in Appendix III.

SUB-COMMITTEE XXII ON PIPE FLANGES AND FITTINGS

Sub-Committee XXII is recommending revisions in the following specifications:

For Alloy-Steel Bolting Material for High-Temperature Service (A 96 – 26);
For Carbon-Steel Castings for Valves, Flanges and Fittings for High-Temperature Service (A 95 – 26 T);[1]
For Forged or Rolled Steel Pipe Flanges for High-Temperature Service (A 105 – 26 T);
For Lap-Welded and Seamless Steel Pipe for High-Temperature Service (A 106 – 26 T).

Some of the revisions represent a radical departure from present requirements but are considered advisable by the sub-committee in view of the unusual service to which materials purchased under these specifications may be subjected.

It is expected that much additional information concerning the behavior of materials under high temperature will be available in the near future from the replies to two questionnaires sent recently to:

(*a*) The oil refineries of the United States;
(*b*) The Central Stations Group, process plants and others using high temperatures.

The first of these questionnaires was sponsored by the Manufacturers Standardization Society, the second by our own Society.

The revisions recommended include in each specification, changes in either or both the chemical and physical requirements and an extension of the time limit in which rejections based on test shall be reported. In the Specification for Steel Castings for Valves, Flanges and Fittings for High-Temperature Service (A 95 – 26 T), the changes include elimination of crucible and converter steel, the fixing of rejection limits of chemical composition while retaining the present physical requirements, and changes in the clauses covering hydrostatic test and marking.

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[1] The proposed revisions of these specifications were not accepted at the annual meeting but were referred back to Committee A-1 for further consideration.—ED.

This report has been submitted to letter ballot of the committee, which consists of 171 members, of whom 110 have voted affirmatively, 7 negatively, and 54 have refrained from voting.

Respectfully submitted on behalf of the committee,

J. B. YOUNG,
Chairman.

G. H. WOODROFFE,
Secretary.

EDITORIAL NOTE

The tentative revisions of the following standard specifications were approved at the annual meeting and were subsequently adopted by letter ballot of the Society on September 1, 1927: for Silico-Manganese-Steel Bars for Automobile and Railway Springs; for Carbon-Steel and Alloy-Steel Forgings; for Quenched-and-Tempered Carbon-Steel Axles, Shafts and Other Forgings for Locomotives and Cars; for Carbon-Steel Bars for Vehicle and Automobile Springs; for Carbon-Steel Bars for Railway Springs; for Chrome-Vanadium-Steel Bars for Automobile and Railway Springs; for Quenched-and-Tempered Alloy-Steel Axles, Shafts and Other Forgings for Locomotives and Cars; for Carbon-Steel Bars for Railway Springs with Special Silicon Requirements; for Boiler and Firebox Steel for Stationary Service; and for Lap-Welded and Seamless Steel and Lap-Welded Iron Boiler Tubes. The specifications as revised appear in the 1927 Book of A.S.T.M. Standards, Part I.

The proposed revisions of the Standard Specifications for Welded and Seamless Steel Pipe, modified as indicated in the Summary of the Proceedings, page 24, were approved at the annual meeting by a nine-tenths vote and were subsequently adopted by letter ballot of the Society on September 1, 1927. The specifications as revised appear in the 1927 Book of A.S.T.M. Standards, Part I. The proposed revisions of the Standard Specifications for Alloy-Steel Bolting Material for High-Temperature Service; and for Carbon-Steel Forgings for Locomotives, were approved at the annual meeting by a nine-tenths vote and were subsequently adopted by letter ballot of the Society on September 1, 1927. The specifications as revised appear in the 1927 Book of A.S.T.M. Standards, Part I. The Standard Specifications for Automotive Carbon and Alloy Steels were withdrawn.

The following tentative specifications were approved at the annual meeting and subsequently adopted by letter ballot of the Society on September 1, 1927: for Open-Hearth Carbon-Steel Rails; for the Manufacture of Open-Hearth Steel Girder Rails of Plain, Grooved and Guard Type; for Low-Carbon-Steel Track Bolts; for Cold-Drawn Steel Wire for Concrete Reinforcement; for Carbon-Steel Car and Tender Axles; for Steel Plates of Structural Quality for Forge Welding; for Steel Plates of Flange Quality for Forge Welding; for Carbon-Steel Castings for Railroads; for Commercial Quality Hot-Rolled Bar Steels; for Commercial Cold-Finished Bar Steels and Cold-Finished Shafting;

and for Structural Silicon Steel. The specifications appear in the 1927 Book of A.S.T.M. Standards, Part I.

The proposed revisions of the Tentative Specifications for Forged or Rolled Steel Pipe Flanges for High-Temperature Service; for Lap-Welded and Seamless Steel Pipe for High-Temperature Service; and for Cold-Rolled Strip Steel were accepted. The specifications as revised appear on pages 663, 667 and 672, respectively. The proposed revisions of the Tentative Specifications for Carbon-Steel Castings for Valves, Flanges, and Fittings for High-Temperature Service were referred back to the committee for further study and report.

The proposed Tentative Specifications for Structural Steel for Locomotives and Cars; for Marine Boiler Steel Plates; and for Alloy Tool Steel, were accepted for publication as tentative and appear on pages 651, 658 and 676, respectively.

APPENDIX I

REPORT OF SUB-SUB-COMMITTEE ON SIZE AND LOCATION OF TEST COUPONS ON STEEL CASTINGS

The Special Sub-Sub-Committee on Size and Location of Test Coupons submits the following report:

1. No general rule can be laid down for the location and dimensions of test coupons. They must be located so as not to "bleed" the casting and yet must be fed so as to be sound. They must be large enough in cross-section to cast solidly and not be porous or dirty. These are matters for determination in individual cases and must necessarily be determined by manufacturing conditions.

2. Tests reviewed by the committee show that when the flame-cutting is done with reasonable skill, the partial severance of the test-coupon by flame-cutting before annealing of the casting does not affect the properties obtained upon specimens taken from the coupon. The tests show no difference in results from completely attached and partially severed coupons on the same casting.

3. Tests reviewed by the committee show no definite or consistent relation between test results from specimens machined from coupons and results upon specimens machined from the body of the castings to which the coupons were attached. These tests covered a wide variety of sizes (cross-sections) of castings and varying dimensions of coupons in proportion to the cross-section of castings where attached. With castings produced and annealed under good average commercial conditions, the tests show:

   (*a*) A tendency toward lower tensile properties, especially elongation and contraction, on specimens machined from the body of thick castings as compared with results upon specimens machined from attached coupons of the moderate thickness customarily used.

   (*b*) That many other factors influence results beside proportions and locations of test coupons to body of casting, hence no rule more specific than the statement of tendency in (*a*) may safely be stated.

4. The committee recommends no change in the specifications for steel castings in the requirements covering the matter of test coupons and the making of physical tests.

5. The committee submits this as a final report and recommends that it be discharged.

Respectfully submitted on behalf of the committee,

J. A. CAPP,
Chairman.

APPENDIX II

REPORT OF SPECIAL SUB-COMMITTEE ON INVESTIGATION OF SINGLE *versus* DOUBLE-RUN LAP-WELDED PIPE FOR VANSTONING

BASIS OF INVESTIGATION

Based upon the action of Sub-Committee IX on Steel Tubing and Pipe of Committee A-1 on Steel, a special sub-committee was appointed to investigate whether there was any marked difference in Vanstoning results from single process, *versus* double process pipe. This sub-committee consisted of representatives of the Power Piping Society and Crane Co. from the side of the fabricator, and of the National Tube Co. and Youngstown Sheet and Tube Co. from the side of the manufacturer; Mr. H. H. Morgan, representing the general interests, was appointed chairman.

FLANGING PROGRAM

A comprehensive program was developed under which single-run and double-run pipe were produced in 4-in. standard and extra strong weight, 6-in. standard and extra strong weight, 8-in. standard and extra strong weight and 10-in. standard and extra strong weight sizes. Of these eight sizes, the National Tube Co. produced four and the Youngstown Sheet and Tube Co., two. The remaining two sizes were supplied by the Spang-Chalfant Co., who were invited to take part in the program. One-third of each size of pipe was shipped to each of the three fabricators, the Crane Co., the Pittsburgh Valve Foundry and Construction Co. and the National Valve and Manufacturing Co.

Flattening tests were made on specimens cut from each end of each length of pipe and a sufficient amount of material was cut from the ends until satisfactory tests were obtained. In the case of the single-run lengths, this flattening test was made to one-third the diameter of the pipe with the weld at 45 deg. In the case of the double-run pipe, the test was made to one-third the diameter of the pipe with the weld at 90 deg. As a matter of information additional rings were cut from the single-run pipe and flattened with the weld at 90 deg. On the single-run lengths there were a considerable number of pipe ends which withstood the test at 45 deg. but failed with the weld at 90 deg. Such pipe ends did not show any different results in flanging. There is no doubt that the flattening test with the weld at 90 deg. from the point of application of the pressure is much more severe a test of the weld than with the weld at 45 deg. It is fair to assume, therefore, from the results of all of these tests that the method and procedure used in turning the flange or lap is much more important a factor than the strength of the weld in the pipe.

Twelve lengths of approximately 20 ft. each of single-run pipe and twelve lengths of double-run pipe of each size were delivered to each of the three fabricators. A flange was run on each end of each pipe. Before shipment from the mills, the pipe were re-numbered so that the fabricators had no knowledge of which were single and which double-run pipe. The Power Piping Society on behalf of the Pittsburgh Valve Foundry and Construction Co. and the National Valve and Manufacturing Co. retained Robert W. Hunt Co. to furnish a man for detailed examination of the flanges produced. The Crane Co. did likewise. This detailed examination was under the direct personal supervision of Mr. H. H. Morgan, the chairman of the sub-committee.

ADDITIONAL FLANGING

At the meeting of Sub-Committee IX on March 16, 1927, it was proposed that some additional tests be made of flanging some distance back from the mill ends of the pipe. After completion of the flanging program described above, at one of the fabricators' plants one of the pipe sizes showing the best results on flanging and the pipe size showing the worst results on flanging were selected for these additional tests. A length approximately 3 ft. long was cut from one end of each of the 24 pieces of this size. A flange was run on these lengths and subjected to examination on completion.

EXPENSE OF INVESTIGATION

A conservative estimate of the cost of this investigation is $10,000.00. The expense was borne jointly by the manufacturers and fabricators. The manufacturers produced the pipe and furnished it without charge to the fabricators. The fabricators flanged the pipe without charge. The expenses of the chairman will be borne equally by the manufacturers and fabricators.

SUMMARY OF RESULTS

It is the consensus of opinion of the sub-committee that it would not be proper or fair to make public the detailed results of this investigation as it was not the intention in any way that this investigation should make any comparison of the pipe produced by the various manufacturers nor the flanging produced by the various fabricators.

The report, therefore, will summarize the results obtained without indication of the sizes of pipe, the manufacturer, or the specific fabricator. For this reason the sizes of the pipe will be designated as "A" to "H," respectively, "A" the lot showing best and "H" the lot showing worst. The fabricators will be designated as "X," "Y" and "Z."

Exacting examination was made of each flange produced. Any defects whatever produced at the weld were observed. Where these were of a character that the fabricators would normally correct by welding, the defects are termed "Welded" although no welding was performed on any of the flanges produced previous to the examination. Where the welds split open or the opening produced in flanging extended well into the wall or barrel of the pipe proper, the weld is designated as "Failed." "Failed" would mean that normally it would be necessary to cut off the pipe and run on a new flange. The results are given in Table I. It is to be noted, however, that one of

TABLE I.—SUMMARY OF FLANGING RESULTS BY SIZES OF PIPE.

Size	Number of Flanges	Single Run		Number of Flanges	Double Run	
		"Welded"	"Failed"		"Welded"	"Failed"
A	72	0	0	72	1	0
B	72	1	0	72	1	0
C	72	1	1	72	1	0
D	72	1	0	72	3	1
E	72	5	1	72	1	2
F	72	9	0	72	0	1
G	72	18	0	72	6	0
H	72	18	26	72	8	14
Totals	576	53	28	576	21	18

TABLE II.—GROUP COMPARISON OF SIZES.

Portion of Total Program	Sizes	Single Run		Double Run	
		"Welded"	"Failed"	"Welded"	"Failed"
$\frac{1}{8}$	A	0	0	1	0
$\frac{1}{4}$	A and B	1	0	2	0
$\frac{3}{8}$	A to C, incl	2	1	3	0
$\frac{1}{2}$	A to D, incl	3	1	6	1
$\frac{5}{8}$	A to E, incl	8	2	7	3
$\frac{3}{4}$	A to F, incl	17	2	7	4
$\frac{7}{8}$	A to G, incl	35	2	13	4
All	A to H, incl	53	28	21	18

the three fabricators would expect to weld such failed flanges, on his experience that the same failures would result in any new flanges produced on the particular length of pipe.

The totals indicated in Table I may be somewhat misleading, due to the bad run of pipe size "H." It is, therefore, important to consider accumulated results as indicated in Table II.

TABLE III.—COMPARISON FABRICATING PRACTICE.
(With separation single and double run process).

Size	Fabricator X				Fabricator Y				Fabricator Z			
	"Welded"		"Failed"		"Welded"		"Failed"		"Welded"		"Failed"	
	S	D	S	D	S	D	S	D	S	D	S	D
A..........	0	0	0	0	0	1	0	0	0	0	0	0
B..........	0	0	0	0	1	1	0	0	0	0	0	0
C..........	0	0	0	0	1	1	1	0	0	0	0	0
D..........	0	0	0	0	1	2	0	0	0	1	0	1
E..........	1	0	0	0	3	1	0	1	1	0	1	1
F..........	0	0	0	0	7	0	0	1	2	0	0	0
G..........	0	0	0	0	13	3	0	0	5	3	0	0
H..........	4	3	0	0	10	2	7	3	4	3	19	11
Total...	5	3	0	0	36	11	8	5	12	7	20	13

TABLE IV.—GROUP COMPARISON BY FABRICATOR.
(With separation single and double run process).

Sizes	Number of Flanges	Fabricator X				Fabricator Y				Fabricator Z			
		"Welded"		"Failed"		"Welded"		"Failed"		"Welded"		"Failed"	
		S	D	S	D	S	D	S	D	S	D	S	D
A..............	48	0	0	0	0	0	1	0	0	0	0	0	0
A and B........	96	0	0	0	0	1	2	0	0	0	0	0	0
B to C, incl.....	144	0	0	0	0	2	3	1	0	0	0	0	0
A to D, incl....	192	0	0	0	0	3	5	1	0	0	1	0	1
A to E, incl.....	240	1	0	0	0	6	6	1	1	1	1	1	2
A to F, incl.....	288	1	0	0	0	13	6	1	2	3	1	1	2
A to G, incl.....	336	1	0	0	0	26	9	1	2	8	4	1	2
A to H, incl....	384	5	3	0	0	36	11	8	5	12	7	20	13

The flanging practice of the fabricator is an important consideration in connection with the matter of "Welded" and "Failed" specimens and it is necessary to set up the total of "Welded" and "Failed" pipes at each of the fabricators designated "X," "Y" and "Z," as given in Table III.

Because of the effect on the totals of the bad run of pipe "H," the accumulated results are indicated in the Table IV.

At one of the three fabricating plants, one of the good runs, size "B," and the bad run size "H," were selected for reflanging.

One of the two ends, properly identified was cut off at approximately 3 ft. and re-flanged with results as follows:

Size "B."—No "Welded" or "Failed" were found on any of the flanges originally rolled or those re-rolled at 3 ft. from the original flange.

Size "H."—On the 12 single-run ends originally rolled there were 9 failed, 2 welded and one satisfactory. On the re-flanging there were one failed, 4 welded and 7 satisfactory. The re-flanging showed an improvement on 8 and showed the same on 4.

On the 12 double-run ends originally rolled there were 7 failed, 2 welded and 3 satisfactory. On the re-flanging there were 2 failed, 2 welded and 8 satisfactory. The re-flanging showed an improvement on 7 with 4 the same and one worse.

ANALYSIS OF RESULTS

A careful analysis of the detailed results of this investigation warrants the following statement.

Generally speaking, so far as Vanstoning, lapping or flanging is concerned, the results of the tests indicate that there is no material difference between single and double process pipe. It would appear from consideration of the results of lots F, G, and H that the double process has strengthened the weld but from the fact that lots A to E, inclusive, show practically no difference in flanging results, it would appear that with good flanging practice on pipe of average quality the double process is not necessary for flanging or lapping. The flanging or lapping practice of the fabricator has distinctly more bearing on the results obtained than any other single factor.

Recommendation.—The sub-committee accordingly recommends that action be taken to withdraw[1] the now tentative addition to the Standard Specifications for Welded and Seamless Steel Pipe (Serial Designation: A 53), which reads as follows:

"*Section 2* (*c*).—Lap-welded pipe ordered for flanging shall be given a double welding operation."

and the rewording of the second sentence of Section 6 (*a*) to read as follows:

"Where welded pipe is ordered for flanging the weld in this test shall be located 90 degrees from the line of direction of the applied force."

Respectfully submitted,

H. H. MORGAN, *Chairman*
F. N. SPELLER
G. A. REINHARDT
Power Piping Society by GEO. J. STUART
Crane Co. by M. W. LINK

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[1] These proposed revisions of the Standard Specifications for Welded and Seamless Steel Pipe were withdrawn at the annual meeting, see Summary of Proceedings, p. 24.—ED.

APPENDIX III

PROPOSED REVISIONS IN STANDARDS AND TENTATIVE STANDARDS FOR STEEL

In this appendix are given proposed revisions in certain standard and tentative specifications, which, for convenience, are numbered from 1 to 22, inclusive. In connection with each title is given the reference to the publication in which the specifications appear in their present form.

PROPOSED REVISIONS IN STANDARDS

No. 1.—STANDARD SPECIFICATIONS FOR WELDED AND SEAMLESS STEEL PIPE: A 53 - 24.[1]

(*a*) ***Recommended for Immediate Adoption as Standard:***

Section 1.—Add a footnote to Section 1, which indicates the purposes for which the pipe is intended, to read as follows:

"*Double Welding.*—Unless double welded pipe is specifically called for on the order, single welded pipe may be furnished. When double welded pipe is ordered, the flattening test on crop ends specified in Section 9 shall be made with the weld on the side."

Section 2 (*a*).—Change to read as follows by the addition of the italicized words:

"(*a*) The steel for welded pipe shall be of soft weldable quality made by the bessemer or by the open-hearth process. The steel for seamless pipe shall be made by the open-hearth *or electric-furnace* process."

Section 3.—Change from its present form: namely,

"Open-hearth steel shall conform to the following requirement as to chemical composition:

	LAP-WELDED	SEAMLESS
Phosphorus, per cent.........	not over 0.06	not over 0.05"

to read as follows:

"(*a*) Ladle tests of open-hearth steel shall conform to the following requirement as to chemical composition."

	LAP-WELDED	SEAMLESS
Phosphorus, per cent.........	not over 0.06	not over 0.045

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[1] 1924 Book of A.S.T.M. Standards.

Add to the new Paragraph (*b*) recommended last year to be added to this section a sentence to read as follows:

"(*b*) Drillings for analysis shall be taken from several points around each pipe."

Section 4.—Change the last line of the table of physical properties under Paragraph (*a*) from its present form: namely,

	WELDED		SEAMLESS	
	BESSEMER	OPEN-HEARTH	OPEN-HEARTH, LOW CARBON	OPEN-HEARTH, MEDIUM CARBON
"Elongation in 2 in., per cent..	..	..	40	25"

to read as follows:

"Elongation in 2 in., per cent..	..	30	40	25"

Change Paragraph (*b*) to read as follows by the addition of the italicized words:

"(*b*) The yield point shall be determined by the drop of the beam of the testing machine *or other approved method.*"

Section 5.—Change to read as follows by the addition of the italicized words:

"Pipe shall be tested at the mill to the hydrostatic pressures specified in Table I. *Welded pipe 2 in. and larger shall be jarred near one end while under test pressure.*"

Section 6.[1]—Change Paragraphs (*a*) and (*b*) to read as follows by the addition of the italicized words and the omission of those in brackets:

"(*a*) For lap-welded pipe over 2 in. in [diameter] *nominal size*, a section of pipe [6 in. long] *4 to 6 in. in length* shall be flattened between parallel plates until the distance between the plates is one-third the outside diameter of the pipe with the weld located 45 deg. from the line of direction of the applied force, without developing cracks."

"(*b*) For butt-welded pipe over 2 in. in [diameter] *nominal size*, a section of pipe [6 in. long] *4 to 6 in. in length* shall be flattened between parallel plates until the distance between the plates is 60 per cent of the outside diameter of the pipe with the weld located 45 deg. from the line of direction of the applied force, without developing cracks."

Insert new Paragraphs (*c*) and (*d*) to read as follows, relettering the subsequent paragraph accordingly.

"(*c*) For low-carbon seamless pipe over 2 in. in nominal size, a section of pipe not less than 2½ in. in length shall be flattened between parallel plates until the distance between the plates is one-third the outside diameter of the pipe without developing cracks. In no case need the distance between the plates be less than five times the thickness of the pipe wall.

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[1] Revisions of Paragraph (*a*) and the addition of new Paragraphs (*c*) and (*d*) were proposed in 1926 and accordingly will not require a nine-tenths vote for adoption.

"(*d*) For medium-carbon seamless pipe over 2 in. in nominal size, a section of pipe not less than $2\frac{1}{2}$ in. in length shall be flattened between parallel plates until the distance between the plates is one-half the outside diameter of the pipe without developing cracks. In no case need the distance between the plates be less than seven times the thickness of the pipe wall."

Section 7.[1]—Change to read as follows by the addition of the italicized words and the omission of those in brackets:

"7. For pipe 2 in. or under in [diameter] ***nominal size***, a sufficient length of pipe shall stand being bent cold through 90 deg. around a cylindrical mandrel the diameter of which is 12 times the nominal diameter of the pipe, without developing cracks at any portion and without opening the weld. ***When ordered for close coiling, the pipe shall stand being bent cold through 180 deg. around a mandrel the diameter of which is eight times the diameter of the pipe, without failure.*** [This] ***The bend*** test will not be required on double extra strong pipe over $1\frac{1}{4}$ in. in diameter."

Section 8.—Change to read as follows by the addition of the italicized words and the omission of those in brackets:

"(*a*) Test specimens shall consist of sections cut from a pipe. They shall be smooth on the ends and free from burrs, ***except when made on crop ends taken from welded pipe.***"

"(*b*) Tension test specimens shall be [longitudinal] ***cut longitudinally from the pipe and not flattened. The sides of specimens shall be parallel between gage marks. Pipe may be pulled in full section if desired. Where impractical to pull a test specimen in full thickness the A.S.T.M. standard one-half inch test specimen may be used.***"

"(*c*) All specimens shall be tested [cold] ***at room temperature.***"

Section 9.[1]—Change to read as follows by the addition of the italicized words and the omission of those in brackets:

"One of each of the tests specified in Sections 4, 6 and 7, [may] ***shall*** be made on a length in each lot of 500 or less, of each size. Each length shall be subjected to the hydrostatic test. ***In the case of welded pipe ordered for "flanging" the crop ends cut from each length shall withstand the flattening test specified in Section 6(a).***"

Tables I and II.—Change by the elimination of the $4\frac{1}{2}$, 7, 9 and 11-in. sizes.

Section 14.—Change to read as follows by the addition of the italicized words and the omission of those in brackets:

"For pipe $1\frac{1}{2}$ in. or under in [inside diameter] ***nominal size***, the outside diameter at any point shall not vary more than $\frac{1}{64}$ in. over nor more than $\frac{1}{32}$ in. under the standard [size] ***outside diameter***. For pipe 2 in. or over in [inside diameter] ***nominal size,*** the outside diameter shall not vary more than 1 per cent over or under the standard [size] ***outside diameter. The wall thickness shall not be more than 12.5 per cent under the nominal wall thickness at any point.***"

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[1] Revisions of Sections 7 and 9 were proposed in 1926 and accordingly the revisions indicated will not require a nine-tenths vote for adoption.

(*b*) *Revisions Submitted for Publication as Tentative:*

A comprehensive test on the flanging of single and double run pipe is now being conducted by Sub-Committee IX to determine the advisability of specifying double run pipe for flanging (van stoning) purposes. The test results at the time of the March meeting of Committee A-1 were not sufficiently advanced to be conclusive. The committee therefore recommends that the following revisions proposed in 1926 be continued as tentative for a year, or eliminated altogether if the final results of the tests indicate that double running of pipe for flanging (vanstoning) purposes, is unnecessary.[1]

Section 2.—Add a new Paragraph (*c*) to read as follows:

"(*c*) Lap-welded pipe ordered for flanging shall be given a double welding operation."

Section 6.—Add a sentence to Paragraph (*a*) to read as follows:

"Where welded pipe is ordered for flanging, the weld in this test shall be located 90 deg. from the line of direction of the applied force."

NO. 2.—STANDARD SPECIFICATIONS FOR ALLOY-STEEL BOLTING MATERIAL FOR HIGH-TEMPERATURE SERVICE: A 96 – 26.[2]

Section 1.—Add a new Paragraph (*d*) to read as follows:

"(*d*) Carbon steel nuts and washers for use with this bolting material are covered in Section 16."

Section 7 (*a*).—Change the phosphorus requirement in the table of chemical requirements from 0.04 to 0.045 per cent.

Section 9.—Change to read as follows by the omission of the words and figures in brackets:

"Analyses may be made by the purchaser from samples representing the bolting material. The chemical composition thus determined shall conform to the requirements specified in Section 7, [except that the rejection limit for phosphorus shall be 0.05 per cent and for sulfur 0.055 per cent]."

Section 16.—Change from its present form: namely,

"Bolts and studs shall be equipped with cold-punched semi-finished carbon-steel nuts of U. S. Standard rough dimensions, chamfered and trimmed. If washers are used under nuts they shall be of forged or rolled steel. All nuts and washers shall be free from injurious defects and shall have a workmanlike finish, and shall conform to the chemical requirements for phosphorus and sulfur specified in Sections 7(*a*) and 9."

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[1] The report on flanging single-run and double-run pipe appears as Appendix II to the Report of Committee A-1. In the light of this report, the proposed revisions were withdrawn.—ED.

[2] A.S.T.M. Standards Adopted in 1926.

to read as follows:

> "16. Bolts and studs shall be equipped with semi-finished carbon-steel nuts of U. S. Standard rough dimensions, chamfered and trimmed. If washers are used under nuts, they shall be of forged or rolled steel. All nuts and washers shall be free from injurious defects and shall have a workmanlike finish. Nuts shall conform to the chemical requirements for phosphorus and sulfur as follows:

	Class A	Class B
Phosphorus, per cent, not over	0.045	0.05
Sulfur, per cent, not over	0.05	0.15"

Section 20 (*a*).—Change to read as follows by the addition of the italicized word and the omission of the word in brackets:

> "Unless otherwise specified, any rejection based on tests made in accordance with Section 19(*b*) shall be reported within [five] *twelve* working days from the receipt of samples."

No. 3.—Standard Specifications for Carbon-Steel Forgings for Locomotives: A 20 – 21.[1]

Section 1.—Change to read as follows by the addition of the italicized words and the omission of the word in brackets:

> "These specifications cover untreated and annealed carbon-steel driving axles, engine and trailing-truck axles, main and side rods, straps, crank pins, [and] piston rods, *and annealed car and tender axles*."

No. 4.—Standard Specifications for Automobile Carbon and Alloy Steels: A 29 – 24.[1]

It is recommended that these specifications be withdrawn.

PROPOSED REVISIONS IN TENTATIVE STANDARDS

No. 5.—Tentative Specifications for Carbon Steel Rails: A 1 – 26 T.[2]

Section 3.—Change "Phosphorus, minimum per cent" in the list of elements considered to "Phosphorus, maximum per cent."

Section 11.—Change from its present form: namely,

> "Standard length of rails shall be 39 ft. at a temperature of 15.5° C. (60° F.) Eleven per cent of the entire order will be accepted in shorter lengths varying by 1 ft. from 38 ft. to 25 ft. A variation of $\frac{3}{8}$ in. from the specified length will be allowed, except that on 15 per cent of the order a variation of $\frac{7}{16}$ in. will be allowed."

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[1] 1924 Book of A.S.T.M. Standards.

[2] *Proceedings*, Am. Soc. Testing Mats., Vol. 26, Part I, p. 621 (1926); also 1926 Book of A.S.T.M. Tentative Standards, p. 17.

to read as follows:

"The standard length of rails shall be 39 ft. or 33 ft., as ordered, when measured at a temperature of 15.5° C. (60° F.). When the length specified is 39 ft., 11 per cent of the entire order will be accepted in shorter lengths varying by 1 ft. from 38 ft. to 25 ft., and a variation of ⅜ in. from the specified length will be allowed, except that on 15 per cent of the order a variation of $\frac{7}{16}$ in. will be allowed.

"When the specified length is 33 ft., 10 per cent of the entire order will be accepted in shorter lengths varying by 1 ft. from 32 ft. to 25 ft., and a variation of ¼ in. from the specified length will be allowed, except that on 15 per cent of the order a variation of ⅜ in. will be allowed."

Section 18 (*b*).—Change to read as follows by the addition of the italicized words:

"(*b*) Rails *of A.R.A. type of sections* arriving at the straightening presses with sharp kinks or greater camber than that indicated by a middle ordinate of 6 in. in 39 ft. *or 4 in. in 33 ft. Rails of A.S.C.E. type of sections arriving at the straightening presses with sharp kinks or greater camber than that indicated by a middle ordinate of 7 in. in 39 ft. or 5 in. in 33 ft.*"

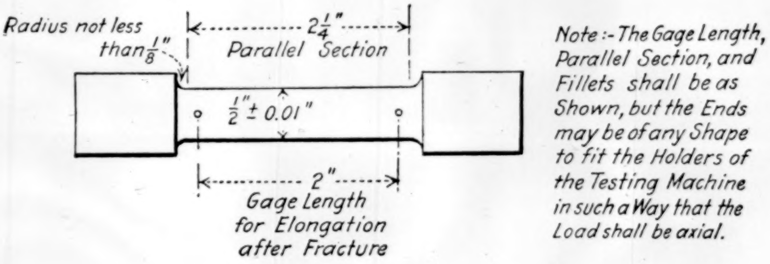
Radius not less than ⅛"
2¼"
Parallel Section
½" ± 0.01"
2"
Gage Length for Elongation after Fracture
Note:-The Gage Length, Parallel Section, and Fillets shall be as Shown, but the Ends may be of any Shape to fit the Holders of the Testing Machine in such a Way that the Load shall be axial.

FIG. 1.

Section 19 (*c*).—Change to read as follows by the addition of the italicized words:

"The top rails shall normally be lettered "A" and *the* succeeding ones "B," "C," "D," "E," etc., consecutively, but in case *the* top discard is greater than normal, the rail lettering shall conform to the amount of discard, the top rail becoming "B" or other succeeding letter to suit the condition.

"Only the "A," "B" and "C" rails are required to be lettered when the normal weight per yard is less than 70 lb."

NO. 7.—TENTATIVE SPECIFICATIONS FOR LOW-CARBON STEEL TRACK BOLTS: A 76 – 20 T.[1]

Section 5.—Add a new line to the table of physical properties, to read as follows:

"Elongation in 2 in., min., per cent........................22."

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. XX, Part I, p. 504 (1920); also 1926 Book of A.S.T.M. Tentative Standards, p. 33.

Section 7.—Change to read as follows by the addition of the italicized words:

"Tension and bend test specimens shall be taken *from a finished bolt or* from the full-size rolled bars. Tension test specimens shall be of 8-in. gage length *when taken from the rolled bars. When taken from a finished bolt the tension test specimen shall conform to the dimension shown in Fig. 1.*"

NO. 8.—TENTATIVE SPECIFICATIONS FOR COLD-DRAWN STEEL WIRE FOR CONCRETE REINFORCEMENT: A 82 – 21 T.[1]

Section 1.—Change to read as follows by the addition of the italicized figures and the omission of those in brackets.

"These specifications cover cold-drawn steel wire to be used as such, or in fabricated form, for the reinforcement of concrete, in gages not less than 0.080 in. nor greater than [0.500] *0.625* in."

NO. 9.—TENTATIVE SPECIFICATIONS FOR CARBON STEEL CAR AND TENDER AXLES: A 21 – 25 T.[2]

Section 1.—Change to read as follows by the addition of the italicized words and figures and the omission of those in brackets:

"These specifications cover tapered axles up to and including those 6½ in. in nominal diameter at the center. Axles over 6½ in. in diameter at the center shall be [purchased under the] *annealed and shall be in accordance with the* Standard Specifications for Carbon-Steel Forgings for Locomotives (Serial Designation: A 20) of the American Society for Testing Materials."

NO. 10.—TENTATIVE SPECIFICATIONS FOR STEEL PLATES OF STRUCTURAL QUALITY FOR FORGE WELDING: A 78 – 23 T.[3]

Section 1.—Change to read as follows by the addition of the italicized words:

"These specifications cover steel plates of structural quality suitable for forge welding, without the use of fluxes, *where the weld is not reinforced.*"

NO. 11.—TENTATIVE SPECIFICATIONS FOR STEEL PLATES OF FLANGE QUALITY FOR FORGE WELDING: A 89 – 23 T.[4]

Section 1.—Change to read as follows by the addition of the italicized words:

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 21, Part I, p. 459 (1921); also 1926 Book of A.S.T.M. Tentative Standards, p. 49

[2] *Proceedings*, Am. Soc. Testing Mats., Vol. 25, Part I, p. 509 (1925); also 1926 Book of A.S.T.M. Tentative Standards, p. 57.

[3] *Proceedings*, Am. Soc. Testing Mats., Vol. 23, Part I, p. 546 (1923); also 1926 Book of A.S.T.M. Tentative Standards, p. 40.

[4] *Proceedings*, Am. Soc. Testing Mats., Vol. 23, Part I, p. 551 (1923); also 1926 Book of A.S.T.M. Tentative Standards, p. 45.

> "These specifications cover steel plates of flange quality suitable for forge welding, without the use of fluxes, *where the weld is not reinforced.*"

NO. 12.—TENTATIVE SPECIFICATION FOR CARBON-STEEL CASTINGS FOR RAILROADS: A 87 – 22 T.[1]

Section 3.—Change to read as follows by the omission of the words in brackets:

> "The steel may be made by one or more of the following processes: open-hearth, electric furnace, crucible or [side blow] converter."

NO. 13.—TENTATIVE SPECIFICATIONS FOR COMMERCIAL QUALITY HOT-ROLLED BAR STEELS: A 107 – 26 T.[2]

Table I.—Change the manganese requirement of the bessemer screw grade from 0.60–0.80 per cent to 0.60–0.90 per cent.

NO. 14.—TENTATIVE SPECIFICATIONS FOR COMMERCIAL COLD-FINISHED BAR STEELS AND COLD-FINISHED SHAFTING: A 108 – 26 T.[3]

Section 1 (a).—Change to read as follows by the addition of the italicized words:

> "These specifications cover commercial cold-finished bar steels of grades considered to be in common use, including cold-finished bessemer screw stock and cold-finished open-hearth screw stock, also cold-finished shafting *and commercial key stock.*"

Table I.—Change the manganese requirement for bessemer screw grade from 0.60–0.80 to 0.60–0.90 per cent.

Table III.—Change from its present form: namely,

PERMISSIBLE VARIATIONS IN THE SIZES OF COLD-FINISHED BARS.

Sizes Specified	Variations in Size, in.					
	Rounds and Hexagons		Squares		Flats, Width and Thickness	
	Under	Over	Under	Over	Under	Over
Up to 0.3 in., inclusive	0.002	0	0.0025	0.0025	0.003	0.003
Over 0.3 to 1 " "	0.003	0	0.0025	0.0025	0.003	0.003
" 1 to 2½ " "	0.004	0	0.004	0.004	0.004	0.004
" 2½ in.	0.005	0	0.005	0.005	0.005	0.005

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 22, Part I, p. 560 (1922); also 1926 Book of A.S.T.M. Tentative Standards, p. 51.

[2] *Proceedings*, Am. Soc. Testing Mats., Vol. 26, Part I, p. 652 (1926); also 1926 Book of A.S.T.M. Tentative Standards, p. 82.

[3] *Proceedings*, Am. Soc. Testing Mats., Vol. 26, Part I, p. 656 (1926); also 1926 Book of A.S.T.M. Tentative Standards, p. 86.

to read as follows:

PERMISSIBLE VARIATIONS IN THE SIZES OF COLD-FINISHED BARS.

Specified Dimensions	Variations in Diameter, Thickness or Width, in.							
	Rounds and Hexagons		Squares		Flats up to 1½ in., inclusive, in Width		Flats over 1½ in., in Width	
	Under	Over	Under	Over	Under	Over	Under	Over
Up to 0.3 in., inclusive...	0.002	0	0.003	0	0.003	0	0.005	0
Over 0.3 to 1 " " ...	0.003	0	0.004	0	0.004	0	0.005	0
" 1 to 2½ " " ...	0.004	0	0.005	0	0.005	0	0.006	0
" 2½ " ...	0.005	0	0.006	0	....	..	....	..
" 2½ to 4 " " ...	....	..	....	..	....	..	0.007	0
" 4 to 6 " " ...	....	..	....	..	....	..	0.010	0

Section 7.—Change from its present form: namely,

"The variation from the specified diameter, or distance between parallel faces, shall not exceed the limits specified in Tables III and IV."

to read as follows:

"(*a*) The variations from the specified diameters, or distances between parallel faces, of cold-finished bars specified in carbon up to and including 0.30 per cent, shall not exceed the limits specified in Table III. For bars specified in carbon over 0.30 per cent, the variations shall be a matter of agreement between the purchaser and the manufacturer."

"(*b*) The variations from the specified diameters of cold-finished shafting shall not exceed the limits specified in Table IV."

NO. 16.—TENTATIVE SPECIFICATIONS FOR CARBON-STEEL CASTINGS FOR VALVES, FLANGES AND FITTINGS FOR HIGH-TEMPERATURE SERVICE: A 95 – 26 T.[1]

These specifications have been extensively revised and are appended hereto in their proposed revised form.[2]

NO. 17.—TENTATIVE SPECIFICATIONS FOR FORGED OR ROLLED STEEL PIPE FLANGES FOR HIGH-TEMPERATURE SERVICE: A 105 – 26 T.[3]

Section 1 (b).—Change to read as follows by the addition of the italicized words:

"Three classes of material are covered, designated Class A, B and C respectively. Class A is intended for forge welding and is classified by the chemical properties as specified in Sections 6(*a*) and (*b*) *and by the physical properties as specified in Section 9*(*a*). Classes B and C are classified in accordance with their physical properties as specified in Section 9(*a*)."

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 26, Part I, p. 637 (1926); also 1926 Book of A.S.T.M. Tentative Standards, p. 67.

[2] The specifications in their proposed revised form were appended to the Report of Committee A-1 as preprinted. They were referred back by the annual meeting for reconsideration by the committee. They accordingly do not appear in this volume.—ED.

[3] *Proceedings*, Am. Soc. Testing Mats., Vol. 26, Part I, p. 642 (1926); also 1926 Book of A.S.T.M. Tentative Standards, p. 72.

Section 5 (*a*).—Change to read as follows by the addition of the italicized word and figure:

"Class A steel does not require heat treatment (*Note 2*)."

Add an additional explanatory note, to read as follows:

"NOTE 2.—It is recommended that Class A flanges and pipe be annealed or normalized following the forge welding operation."

Section 6.—Change the table of chemical properties, appearing in Paragraph (*a*), by the addition of the following requirement:

	CLASS A	CLASSES B AND C
"Silicon, per cent, not over..........	0.40	...."

Change Paragraph (*b*) to read as follows by the addition of the italicized words and figures and the omission of those in brackets:

"The carbon content of Class A material shall not exceed [0.17 per cent] *0.20 per cent*. The carbon content of Class B and C *material* shall be a matter of agreement between the purchaser and the manufacturer."

Section 9 (*a*).—Change the table of physical requirements appearing in Section 9 (*a*) by the following addition of requirements for Class A flanges to read as follows:

	Flanges for Forge Welding	Flanges not for Forge Welding	
	Class A	Class B	Class C
Tensile strength, lb. per sq. in............	*54 000*	60 000	70 000
Yield point, lb. per sq. in.................	*30 000*	30 000	36 000
Elongation in 2 in., per cent..............	*25.0*	25.0	22.0
Reduction of Area, per cent...............	*38.0*	38.0	30.0

Section 10 (*a*).—Change to read as follows by the omission of the words in brackets:

"[For Classes B and C] one tension test shall be made from each melt or for each annealing or normalizing charge. If more than one melt is represented in any annealing or normalizing charge, a test shall be made from each melt."

Section 16 (*a*).—Change to read as follows by the addition of the italicized word and the omission of the word in brackets:

"Unless otherwise specified, any rejection based on tests shall be reported within [five] *twelve* working days from the receipt of samples."

NO. 18.—TENTATIVE SPECIFICATION FOR LAP WELDED AND SEAMLESS STEEL PIPE FOR HIGH-TEMPERATURE SERVICE: A 106 – 26 T.[1]

These specifications have been extensively revised and are appended hereto in their proposed revised form.[2]

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 26, Part I, p. 646 (1926); also 1926 Book of A.S.T.M. Tentative Standards, p. 76.

[2] See p. 667.—ED.

NO. 19.—TENTATIVE SPECIFICATIONS FOR COLD-ROLLED STRIP STEEL: A 109 - 26 T.[1]

Section 11 (*a*).—Change from its present form: namely,

"Cold-rolled strip shall be furnished in 8-ft. lengths and ends unless otherwise specified. When so furnished the allowance shall be plus 3 in. with no negative allowance."

to read as follows:

"Cold-rolled strip steel is usually furnished in coils, but may be furnished in cut lengths when ordered. Unless otherwise specified, the cut lengths will be 8 ft. and ends. When so furnished the allowance shall be plus 3 in. with no minus allowance."

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 26, Part I, p. 660 (1926); also 1926 Book of A.S.T.M. Tentative Standards, p. 90.

PROGRESS REPORT OF THE JOINT COMMITTEE ON INVESTIGATION OF THE EFFECT OF PHOSPHORUS AND SULFUR IN STEEL

The Joint Committee on Investigation of the Effect of Phosphorus and Sulfur in Steel was formed in 1919 under the joint initiative of the American Society for Testing Materials, U. S. Bureau of Standards and the then existing U. S. Railroad Administration and is made up of representatives from the following organizations:

U. S. Bureau of Standards;
American Society for Testing Materials;
American Railway Association, Mechanical Division;
U. S. War Department;
U. S. Navy Department;
Society of Automotive Engineers;
Society of Naval Architects and Marine Engineers;
National Research Council;
Association of American Steel Manufacturers;
Steel Founders' Society of America;
American Foundrymen's Association.

The complete investigation planned by the Joint Committee included a study of the effect of sulfur and phosphorus on steel in which the sulfur or phorphorus is residual (Series A) and steel in which the sulfur or phosphorus may be added during the later stages of manufacture in the form of additions to be determined (Series B), The steels to be studied in Series A were classified in six groups:

Group	Material	Approximate Carbon Range, per cent	Approximate Manganese Range, per cent
I.	Rivet Steel, Tubes, etc.	0.06 – 0.12	0.35 – 0.40
II.	Plates and Structural Shapes	0.16 – 0.22	0.35 – 0.40
III.	Forgings	0.45 – 0.55	0.50 – 0.60
IV.	Wheel, Tire and Rail Steel	0.65 – 0.75	0.60 – 0.70
V.	Spring Steels	0.95 – 1.05	0.35 – 0.45
VI.	Castings	....	....

These groups cover practically all of the usual ranges of carbon of the material covered in A. S. T. M. specifications. The committee considered it desirable to investigate first the effect of sulfur and then that of phosphorus, and in each instance considered the effect of "residual" sulfur and phosphorus as the more important.

In 1922, the committee presented its first preliminary report,[1] giving the results of tests to determine the effect of sulfur on rivet steel. This report was supplemented in 1924 by a third preliminary report[2] on Effect of Sulfur on Endurance Properties of Rivet Steel and a fourth preliminary report on Metallographic Investigation on Effect of Sulfur on Rivet Steel.[3] Supplementary tests were also made regarding the gas content of this steel. After studying the data in hand and taking into account studies of steels of certain of the other series the Joint Committee prepared formal conclusions on this series of tests, which were reported to the constituent organizations a year ago.[4]

In 1923, the committee presented a second preliminary report discussing the Effect of "Added" Sulfur on Structural, Forging and Rail Steels. This report covered tests in the above-mentioned Series B material falling within Groups II, III and IV.[5]

In 1924, the committee presented a fifth preliminary report[6] describing the tests that had been conducted to determine the Effect of Sulfur on Structural Steel, being Series A, Group II, of the schedule. The results of these tests have now been analyzed and certain check tests of impact values have been made and the committee now presents, in a report accompanying the present one, its report on Conclusions on the Effect of Sulfur on Structural Steel.

The next group of tests to be undertaken was that of the effect of sulfur on forging steels, that is, Series A, Group III, of the schedule. Material for this group was furnished in seven heats ranging in sulfur from approximately 0.03 to 0.10 per cent and was supplied in the form of 1-in. rolled rounds, 2-in. hammered rounds and 8-in. pressed rounds, to be tested in annealed and quenched-and-drawn conditions. Tests of the 1-in. rounds have been completed and tests on the 2 and 8-in. rounds partially completed. Results of tests on some of the larger size material have made it advisable to secure further material and to make further tests before reporting, particularly in view of the great economic importance of this type of material. The Association of American Steel Manufacturers and the firm originally furnishing the material have concurred in this decision of the committee. Arrangements are now being made to secure additional material which as before will be manufactured under the immediate supervision of the committee.

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 22, Part I, p. 94 (1922).

[2] *Proceedings*, Am. Soc. Testing Mats., Vol. 24, Part I, p. 96 (1924).

[3] *Ibid.*, p. 108.

[4] *Proceedings*, Am. Soc. Testing Mats., Vol. 26, Part I, p. 114 (1926).

[5] *Proceedings*, Am. Soc. Testing Mats., Vol. 23, Part I, p. 105 (1923).

[6] *Proceedings*, Am. Soc. Testing Mats., Vol. 24, Part I, p. 185 (1924).

The committee is discussing with the Association of American Steel Manufacturers the procurement of material for Series A, Group IV, covering wheel, tire and rail steels.

The Joint Committee has decided not to proceed with tests to determine the effect of sulfur on the Group V, Series A, steels. These are steels of high carbon and in view of the fact that trouble from high sulfur is not common in spring steels and also due to the difficulty of properly testing the material, it was decided to omit this part of the program.

The Joint Committee has discussed with the steel foundrymen, who are represented in the committee's work by the American Foundrymen's Association and the Steel Founders' Society of America, arrangements for an investigation of the effect of sulfur on steel castings. After full consideration it was decided not to make these tests, the steel founders explaining that they can see no practical value in the determination of the effect of sulfur on steel castings in view of the fact that as a manufacturing problem sulfur must be kept below a reasonable limit, such as 0.06 per cent, to avoid hot-shortness.

The committee has next turned to that part of its program relating to the determination of effect of phosphorus in steel. It is discussing with the Association of American Steel Manufacturers the advisability of procuring material and program of tests relating to material in Groups I to V. The association recommends that this not be taken up for residual phosphorus. Preliminary discussions with the representatives of the steel founders have been had concerning tests to determine the effect of phosphorus in steel castings. A program of tests has been tentatively prepared calling for tests of cast bars of acid open-hearth steel of two carbon contents, namely, 0.25 per cent desired and 0.45 per cent desired, with desired manganese in each case 0.70 per cent, desired silicon, 0.35 per cent, with sulfur as close as possible to 0.045 per cent, this being approximately the sulfur content of normal acid open-hearth casting steel. The steel is to be as free as possible from nickel, chromium, copper and other elements. In the lower carbon steel five heats are to be secured with phosphorus content, respectively, 0.025, 0.04, 0.06, 0.07 and 0.10 per cent; and in the higher carbon steel, three heats with phosphorus 0.025, 0.05 and 0.07 per cent. In each instance the phosphorus is to be residual, that is, not added in the ladle. Tension, impact, compression, fatigue and torsion tests are to be made on the material in three conditions, annealed, normalized, and normalized and drawn. The program will require 288 bars $1\frac{1}{8}$ in. square by 12 in. long. Details of procurement of the material are now being discussed with representatives of the foundrymen, who have agreed to furnish the material under the immediate supervision of the committee.

Respectfully submitted on behalf of the Joint Committee,

G. K. BURGESS,
Chairman.

C. L. WARWICK,
Secretary.

EFFECT OF SULFUR ON PLATE MATERIAL: CONCLUSIONS

REPORT OF THE JOINT COMMITTEE ON INVESTIGATION OF THE EFFECT OF PHOSPHORUS AND SULFUR IN STEEL

The Fifth Preliminary Report of the Joint Committee on Investigation of the Effect of Phosphorus and Sulfur in Steel[1] contains information relative to the material, heat treatment and test results on structural steel in the form of rolled plates, with sulfur content varying from approximately 0.03 to 0.08 per cent, from which the following conclusions are drawn.

The sulfur present in commercial plate material up to at least 0.077 per cent, which was the highest sulfur content examined, is not detrimental, the tests showing no systematic relation between any of the physical properties determined and the sulfur up to 0.077 per cent.

The following physical properties determined for sheared and universal plate in the natural, normalized, annealed and quenched conditions showed no systematic relation with sulfur up to 0.077 per cent: tensile strength, proportional limit, yield point, elongation, reduction of area, shear and bend tests.

The original Charpy impact tests and subsequent check tests showed such a wide variation of individual results that no deleterious conclusions regarding the effect of sulfur can possibly be drawn from them. It is evident that this particular type of impact test is unsuitable for rolled plate material.

Plotting certain of the physical properties determined from this material against sulfur content, for both sheared and universal plates, tested in directions parallel and transverse to that of rolling, gives a series of curves shown in Figs. 1 and 2. In plotting these curves a base line was first established, which represented the average value of the particular property being plotted for all heats in a given condition. The difference between that average and the actual value of that property for each heat was then plotted above or below the base

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[1] *Proceedings*. Am. Soc. Testing Mats., Vol. 24, Part I, p. 185 (1924).

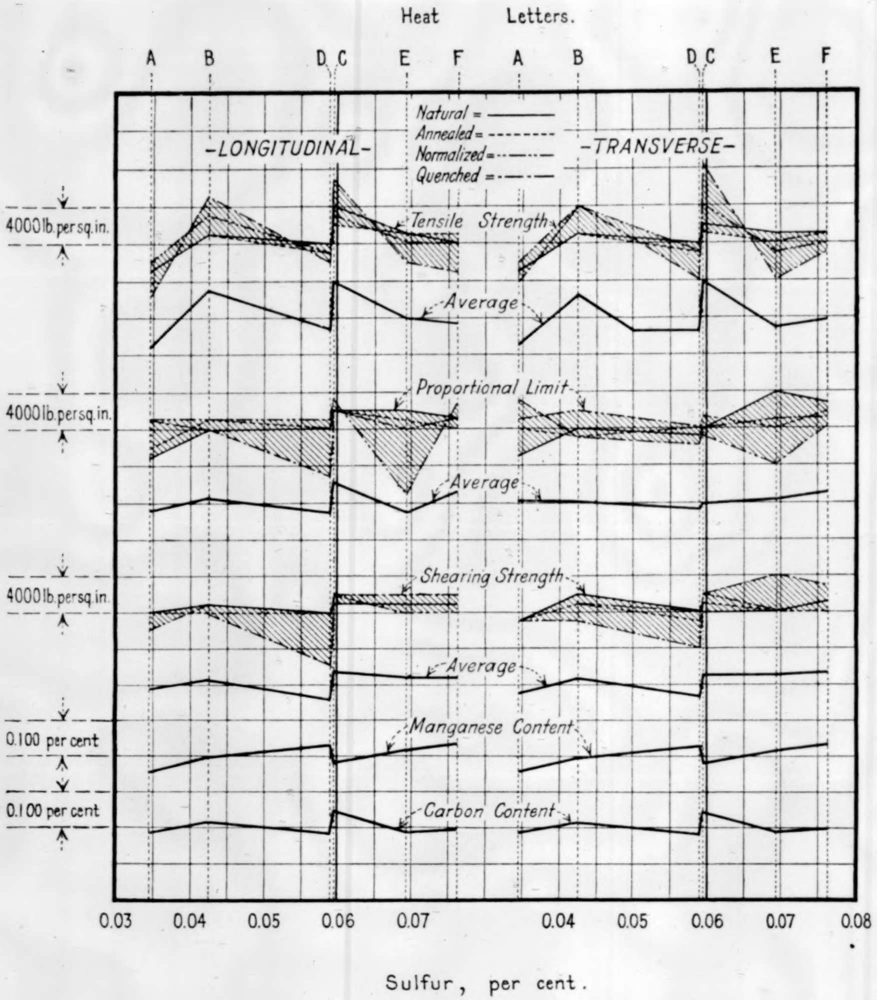

FIG. 1.—Summary Curves for Universal Plate Material, Series A, Group II, Phosphorus and Sulfur Investigation.

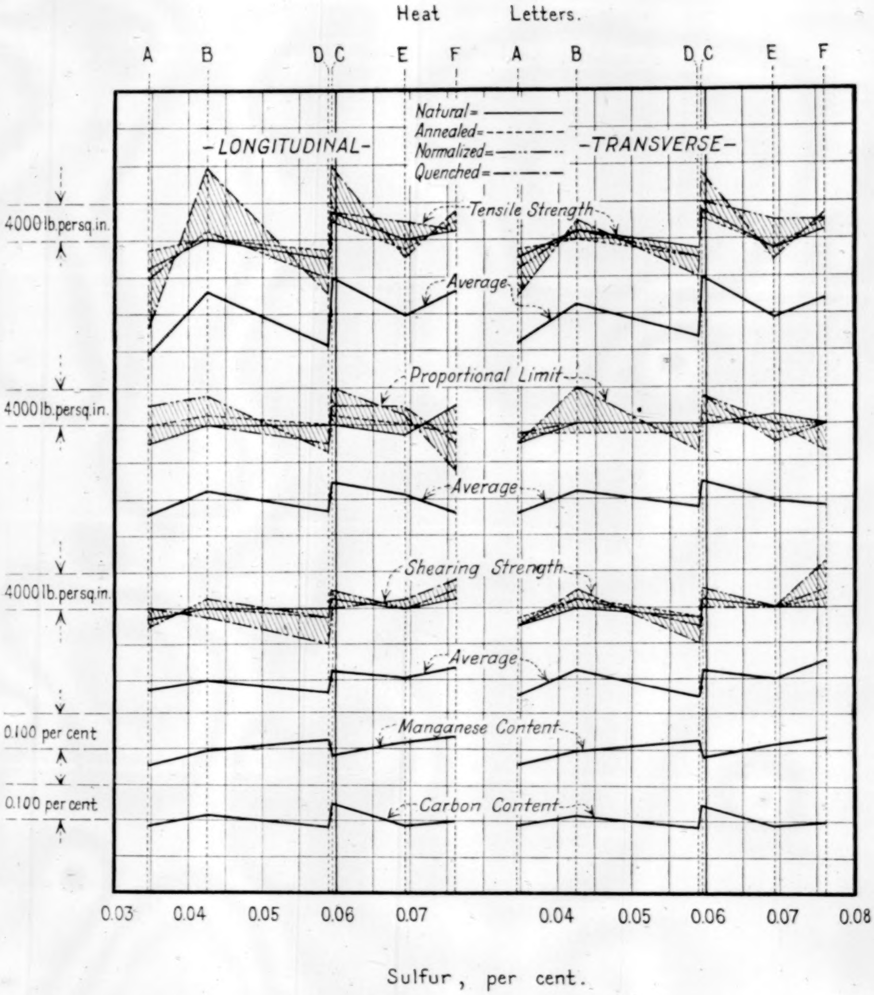

FIG. 2.—Summary Curves for Sheared Plate Material, Series A, Group II, Phosphorus and Sulfur Investigation.

line depending upon whether the difference was positive or negative. Finally the curves thus determined were superimposed by making the base lines coincident. These curves for all physical properties show considerable irregularities which are, however, apparently dependent mainly on the carbon and manganese contents.

Respectfully submitted on behalf of the Joint Committee,

G. K. BURGESS,
Chairman.

C. L. WARWICK,
Secretary.

JOINT RESEARCH COMMITTEE
ON
EFFECT OF TEMPERATURE ON THE PROPERTIES OF METALS

PROGRESS REPORT TO THE SPONSOR SOCIETIES

The Joint Research Committee on Effect of Temperature on the Properties of Metals was permanently organized by the two sponsor societies, the American Society of Mechanical Engineers and the American Society for Testing Materials, following a Symposium on this subject held at a joint meeting of the two societies in Cleveland in May, 1924. The sponsors proposed that the functions of the committee be as follows:

1. Accumulation of existing unpublished data covering satisfactory and unsatisfactory service of various metals under extreme temperatures in different fields of engineering.

2. The making of studies leading to standardization of the procedure for testing materials at high and low temperatures. These should preferably include studies of new comparative tests of metals by the particular methods now in use in various laboratories and, likewise, a critical examination of data already published.

3. Outlining and fostering new research work in this field. The first, and most important, materials to be investigated are considered to be carbon and alloy steels, so-called "heat resisting" alloys consisting of various combinations of nickel, chromium, iron, tungsten, molybdenum, etc., and trimming materials (chiefly alloys of nickel and copper) for valves and equipment intended for high-temperature service in power stations, oil refineries, etc.

Pursuing this program the committee set up a schedule as follows:

1. To list laboratories that are in position to perform tests at elevated temperatures and to complete arrangements with them for a preliminary set of tension tests.

2. To formulate a specification, standardizing the methods of testing, machines to be used, types of test bars for the various tests, methods of temperature determination, methods of determining elongation or strain, etc.

3. To formulate specifications for metals to be tested, and to confer with the various steel companies with the view of obtaining the necessary amount of materials to carry on a preliminary set of tetss.

Sub-committees were appointed within the Joint Research Committee, these sub-committees reporting at a subsequent meeting briefly as follows:

1. Fifty-three laboratories were addressed and their cooperation solicited. Replies were received from thirty-eight laboratories indicating that between twenty and thirty of them had the necessary equipment and were willing to cooperate in this work to the extent of testing a limited number of bars without cost to the committee.

2. Specifications were presented and adopted for short-time and long-time tension tests. Since one of the valuable results to be obtained from the preliminary tests is a determination whether or not it is necessary that all tests, in order to be comparable, should be conducted with a specific type of equipment, it was decided that for this series of tests each laboratory should use its existing equipment, such as testing machine, extensometer, pyrometer, etc.

3. Approximate specifications were formulated for four classes of steel and later augmented by a fifth class, as follows: a low-carbon open-hearth steel, a stainless steel, a chrome-molybdenum open-hearth steel, a heat-resisting alloy such as a nickel-chromium alloy low in iron, and pure nickel.

As these materials were procured, they were properly heat-treated and a supply of test bars of each was sent to four laboratories. These laboratories work independently of one another and are to make individual reports to the committee.

A sub-committee of three members was delegated to analyze and compare the reports from the various laboratories, and from the report of this sub-committee it will be possible to conclude whether or not it is necessary to standardize upon specific types of testing equipment in order to obtain comparable results. The information obtained from these reports will also supply valuable data concerning the tensile properties of these five materials at temperatures between 70 and 1200° F.

Complete reports have been received on the low-carbon open-hearth steel and on the chromium-molybdenum open-hearth steel. These reports are in the hands of the sub-committee for analysis and will be presented to the Joint Research Committee at its June, 1927, meeting. It is probable that the essential information obtained therefrom will be released for publication some time after this meeting.[1]

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[1] Two reports have become available and are appended hereto. Appendix I is a preliminary report by H. J. French on Comparative High-Temperature Tension Tests on a Carbon Steel and on a Chromium-Molybdenum Steel at Different Laboratories. Appendix II is a report by N. L. Mochel on Thermal Expansion of Materials.

It is anticipated that the sub-committee will also have available lantern slides or charts for the purpose of showing in summary form the pertinent facts concerning these materials, as a supplement to this report.

Future Program:

The committee has tentatively formulated a program of the most important tests to be undertaken, as follows:

1. Tension tests, short and long time, now in progress.
2. Chemical stability.
3. Tension tests of non-ferrous metals.
4. Physical and thermal constants.
5. Other mechanical tests, for example, fatigue, impact, torsion, etc.

The foregoing program is of such an extent that it will be necessary to pay for laboratory services. The five foregoing items were, therefore, delegated to sub-committees which have presented reports as to the desirable scope and approximate cost of each item. These reports indicated that approximately $50,000 would be required for one year's work on this program. The method of financing such a program is being discussed with the sponsor societies and will be reported upon at the June meeting of the committee.

Under item No. 4 a committee member volunteered laboratory facilities for the purpose of determining thermal expansivity of the five materials now in the hands of the committee. It is anticipated that this report will be ready for presentation to the committee at the June meeting.

Bibliography:

For the assistance of the members, a bibliography consisting of several hundred titles was prepared by the librarian of Henry L. Doherty and Co. and circularized to the committee members. The American Society of Mechanical Engineers recommended that this bibliography be published in an attractive form with the anticipation that it would stimulate interest in this research work among those not directly connected with the committee, an interest which may prompt financial support. By augmenting the bibliography with a digest of the most pertinent information on the subject, the publication should prove valuable to the research worker and also to the technical executive who is in search of a comprehensive but less detailed knowledge of the subject. The Main Research Committee of the A.S.M.E. has agreed to finance the printing of such a bibliography and it is anticipated that approval of the plan will be voted by the Joint Research Committee.

Service Information:

A sub-committee has drafted a form of questionnaire which is to be submitted to manufacturers of heat-resisting materials and to users of metals under high-temperature service conditions for the purpose of summarizing their experiences, both satisfactory and unsatisfactory, in the use of various materials under such service.

Respectfully submitted on behalf of the Joint Committee,

G. W. SAATHOFF,
Chairman.

F. M. VAN DEVENTER,
Secretary.

APPENDIX I

PRELIMINARY REPORT ON COMPARATIVE HIGH-TEMPERATURE TENSION TESTS ON A CARBON STEEL AND ON A CHROMIUM-MOLYBDENUM STEEL AT DIFFERENT LABORATORIES

INTRODUCTION

At the Symposium on Effect of Temperature on the Properties of Metals held in Cleveland in May, 1924, under the auspices of the American Society of Mechanical Engineers and the American Society for Testing Materials,[1] attention was called to the differences frequently encountered in the results of high temperature tension tests made in different laboratories upon similar metals. It seemed desirable to determine the causes of such differences and whether comparable results could be secured with the procedure and equipment normally employed in different laboratories. Information of this sort might have an added value in that it could furnish the basis for ultimate standardization of high-temperature tension test methods and correlation with creep test data.

COOPERATORS

Over twenty laboratories have cooperated in such an investigation, the cooperating laboratories being represented by numbers pending permission for the committee to credit the results to the organizations concerned. The group which cooperated in the first series of tests was as follows:

Babcock & Wilcox, Bayonne, N. J.
Bureau of Standards, Washington, D. C.
Chapman Valve Manufacturing Co., Indian Orchard, Mass.
Crane Co., Chicago, Ill.
University of Illinois, Urbana, Ill.
University of Michigan, Ann Arbor, Mich.
Walworth Manufacturing Co., Boston, Mass.
Watertown Arsenal, Watertown, Mass.

STEELS TESTED

Results so far received have been obtained on steels K1 and K3 having the chemical compositions shown in Table I. Steel K1 was normalized and steel K3 quenched and tempered prior to test in accordance with the schedule given in Table I.

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[1] See *Proceedings*, Am. Soc. Testing Mats., Vol. 24, Part II, p. 9 (1924).

Equipment and Procedure Employed in the Tests

Each steel was heat treated at a single laboratory and then distributed to the cooperators for tension tests. These tests were made under general requirements furnished by the committee but with equipment and procedure ordinarily employed by the respective organizations. The committee requirements were furnished primarily to insure receipt of adequate information concerning what had actually been done in the tests and the results obtained, and were not intended to control all of the details of equipment or procedure employed. Despite these precautions, considerable difficulty was encountered in interpreting the reports from some of the cooperators and it has therefore not been possible to make a complete analysis of data pending receipt of more detailed information on certain phases of the work.

TABLE I.—CHEMICAL COMPOSITIONS AND OTHER DETAILS OF THE TWO STEELS TESTED

Mark	Chemical Composition, per cent							Rolled to	Preliminary Heat Treatment	Heat Treated by Lab. No.
	Carbon	Manganese	Phosphorus	Sulfur	Silicon	Chromium	Molybdenum			
K1[a]	0.17	0.42	0.012	0.035	....	....	....	1 in. round	1650–1700° F. (900–925° C.), 1 hour cooled in air.	23
K3[a]	0.39	0.51	0.015	0.029	0.19	0.87	0.21	$1\frac{1}{8}$ in. round	1625° F. (885° C.), 2 hours cooled in air; 1550° F. (845° C.), $1\frac{1}{2}$ hours cooled in oil; 1300° F. (705° C.), 2 hours cooled in oil.	13

[a] Analysis made by manufacturer of the steel.

The stress-strain curves credited to laboratory No. 3 are plotted on the assumption that strain was measured on a 2-in. gage length. Actually, the strain was measured between points on the pulling bars, the measured length having included a zone of variable temperature. This does not, however, markedly affect the selection of proportional limits for the purpose of this preliminary report.

Experimental Results

The results of the tension tests at four different laboratories on each of the steels K1 and K3 are shown in Figs. 1 to 4, inclusive.

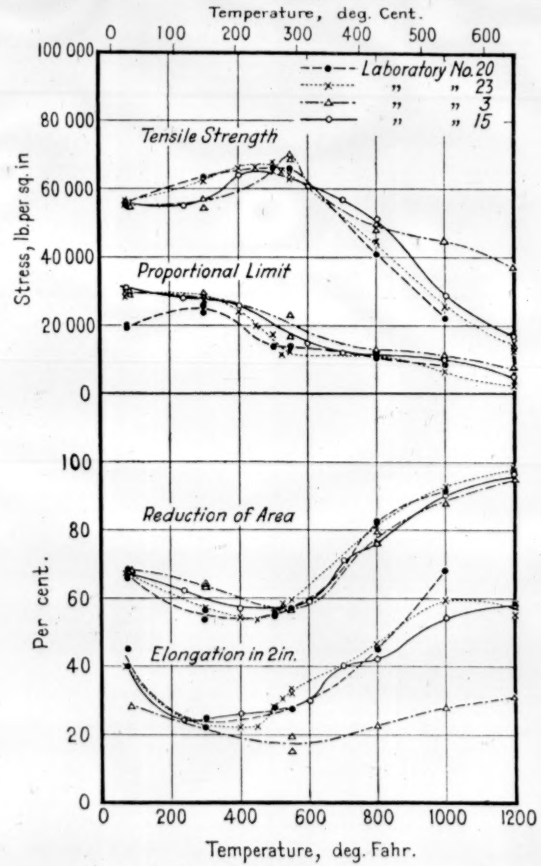

FIG. 1.—Effect of Temperature on the Tensile Properties of 0.17-per-cent Carbon Steel K1 as Determined by Four Different Laboratories.

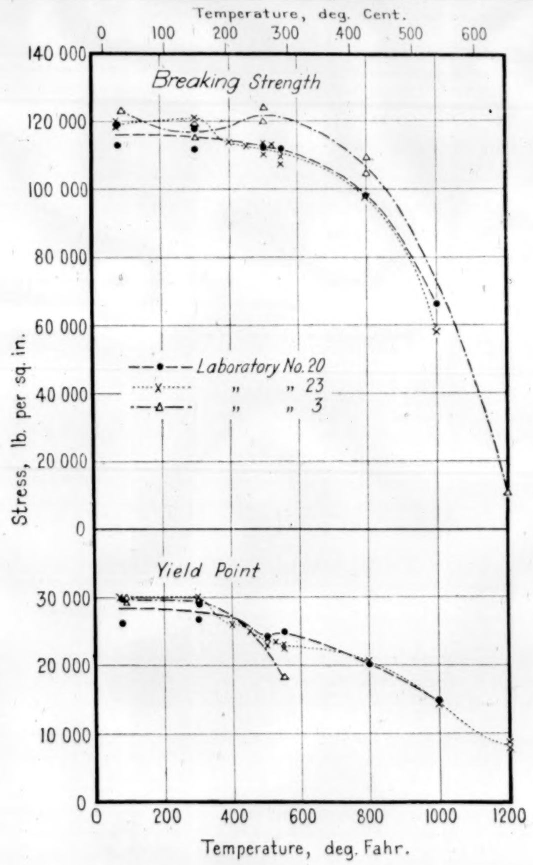

FIG. 2.—Effect of Temperature on the Yield Point and Breaking Strength of 0.17-per-cent Carbon Steel K1 as Determined by Different Laboratories.

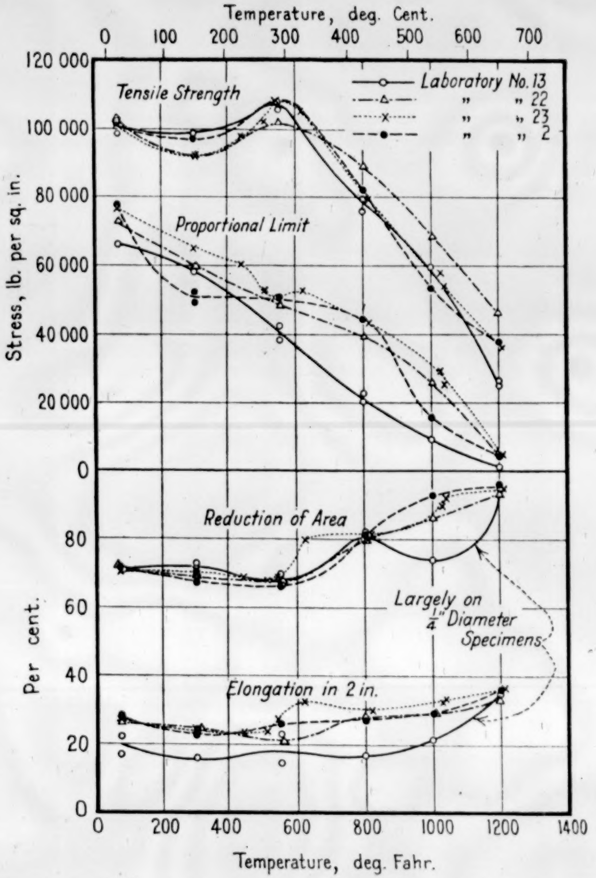

FIG. 3.—Effect of Temperature on the Tensile Properties of Chromium-Molybdenum Steel K3 as Determined by Four Different Laboratories.

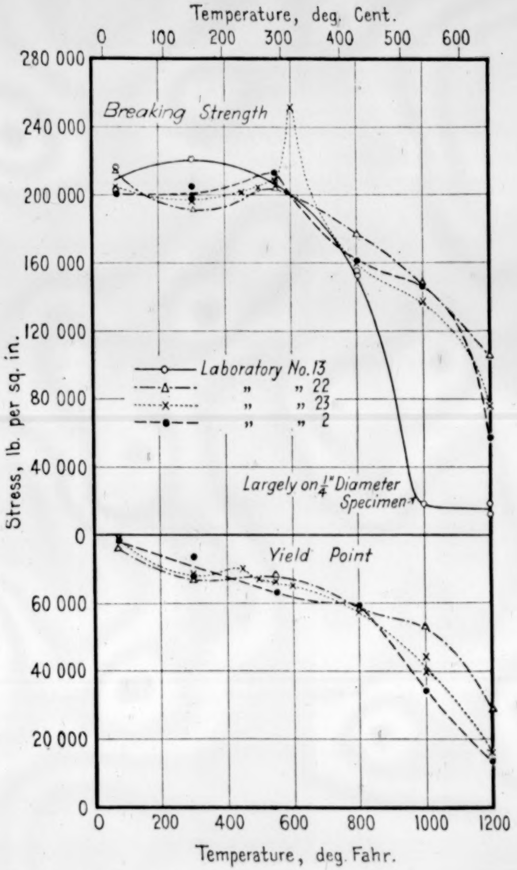

FIG. 4.—Effect of Temperature on the Yield Point and Breaking Strength of Chromium-Molybdenum Steel K3 as Determined by Different Laboratories.

Figures 1 and 3 show the effect of temperature on the tensile strength, proportional limit, elongation and reduction of area as reported by the four cooperators for each steel. Similarly the effect of temperature upon the yield point[1] and breaking strength[2] are shown in Figs. 2 and 4.

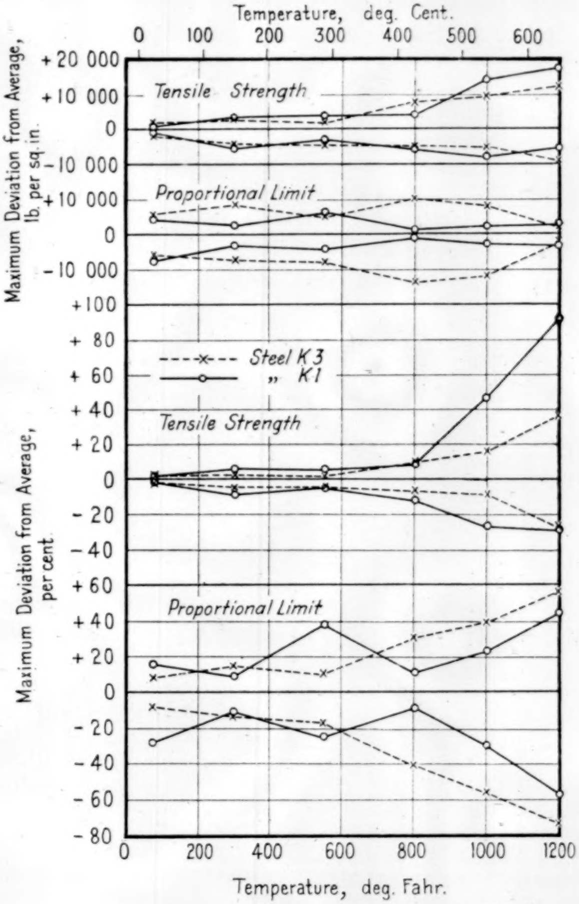

FIG. 5.—Maximum deviation from the average values of tensile strength and proportional limit in the described tests at different temperatures.
Based on data shown in Figs. 1 and 3.

There are some notable differences in the results obtained at the different laboratories on the same metals. For example, the tensile strengths and elongations reported by Laboratory No. 3 for the carbon steel at the highest temperatures are rather far from the values reported for corresponding conditions by the other three laboratories. Likewise in tests of the chromium-molybdenum steel, wide differences are observed in the proportional limits, and above about 800° F. (425° C.) Laboratory No. 22 reports somewhat higher tensile strength values than the other three laboratories. Other important differences are found but require no special discussion as they are clearly shown in Figs. 1 to 4, inclusive.

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[1] This is the stress at which 0.5 per cent strain is observed.

[2] This is the load in pounds at the moment of fracture divided by the area of the fractured section in square inches.

Maximum variations from average values of tensile strength and proportional limit of each of the steels at the different temperatures are summarized in Fig. 5.[1] This chart shows that the actual and percentage deviation from the average tensile strength increases appreciably in the temperature range 800 to 1200° F. (425 to 650° C.), whereas the actual deviation from the average proportional limit shows no definite tendency to increase with temperature. However, the percentage variation from the average proportional limit tends to increase.

The reasons for the increased deviation from the average tensile strength with rise in temperature between 800 and 1200° F. (425 and 650° C.) may be due to the fact that steels are more susceptible to the rate of application of stress at these temperatures than they are at ordinary atmospheric or slightly elevated temperatures. Differences in the "pulling speeds" used in different laboratories, which at ordinary temperatures do not result in noticeable differences in the tensile strength, may cause real differences when the tests are made at temperatures in the range 800 to 1200° F. (425 to 650° C.).

On the other hand, it is possible that such differences are almost wholly associated with temperature measurements and control but this cannot be determined without further detailed data from the cooperators.

Variations from differences in rate of loading in the determination of proportional limits are probably overshadowed by those arising from differences in the sensitivity of extensometers and methods of plotting stress-strain curves. These latter, which are not directly dependent upon the temperature or the properties of the steels, may account for the fact that the maximum variations from the average proportional limits at temperatures around 800 to 1200° F. (425 to 650° C.) are in general no greater than those at atmospheric temperatures. However, since the proportional limit decreases generally with temperature the percentage variation will tend to increase, as is shown in Fig. 5.

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[1] This is based on all reported values.

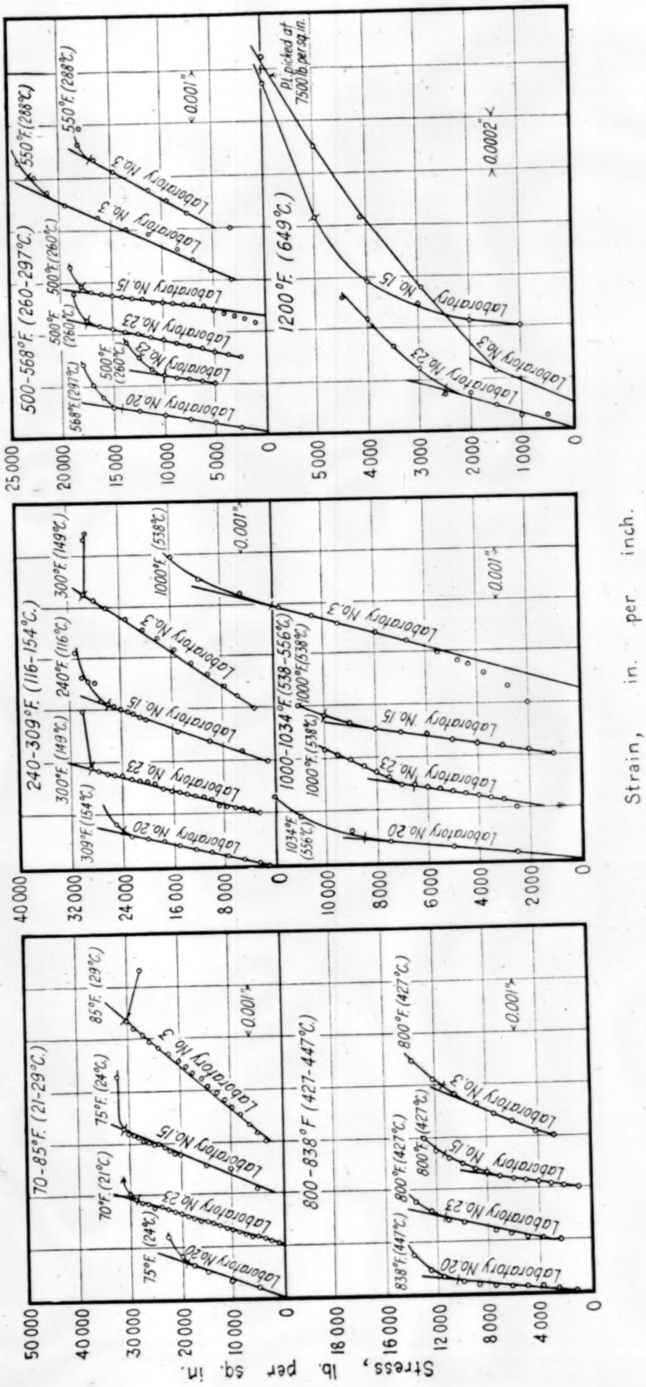

FIG. 6.—Stress-Strain Curves at Different Temperatures Reported by Different Investigators for 0.17-per-cent Carbon Steel K1.

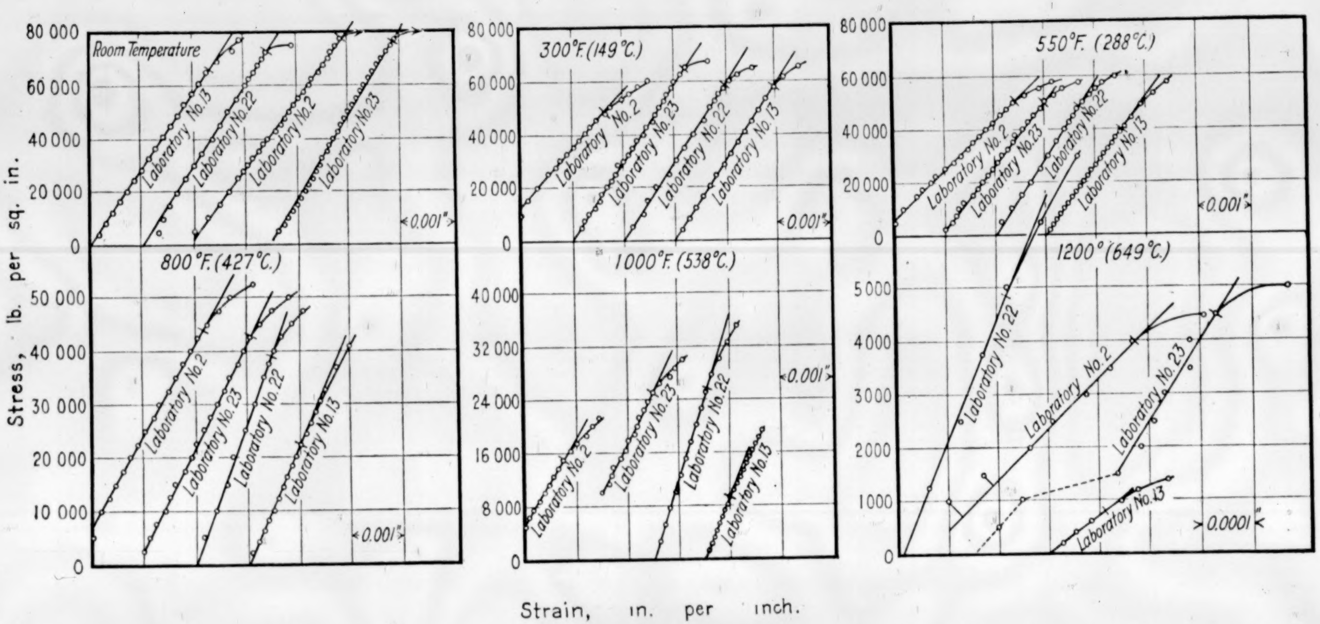

FIG. 7.—Stress-Strain Curves at Different Temperatures Reported by Different Investigators for Chromium-Molybdenum Steel K3.

The dependence of the proportional limit upon the equipment and procedure employed in the tests is shown in Figs. 6 and 7. In these charts typical stress-strain curves obtained by each of the four laboratories on each of the steels K1 and K3 are plotted to the same coordinates at the given temperature. The selected coordinates are not necessarily those used by the individual cooperators in the selection of the proportional limits but were chosen to permit comparison of results. The values of proportional limit originally selected by each laboratory are shown by the short lines which run at about 90 deg. to the modulus line or the slope of the stress-strain curve as the case may be.

The replotting of the stress-strain curves in Figs. 6 and 7 shows that the proportional limits could in some cases have been taken at much lower values than those originally selected. This is most noticeable in the results of tests made by Laboratory No. 15. On the other hand, appreciable differences in some cases are due to differences in the sensitivity of equipment employed to measure strain. For example, in tests of steel K3 at 1200° F. (650° C.), Laboratory No. 13, using an extensometer with smallest direct reading of 0.000004 in., reports a proportional limit at a stress which is below the first point on the stress-strain curves obtained by Laboratories Nos. 2 and 22 using extensometers of much lower sensitivity.

One of the striking features revealed by the stress-strain curves obtained for steel K1 is that the values reported by Laboratory No. 15 for temperatures around 400° F. (205° C.), and above are consistently higher than those reported by Laboratory No. 23 at corresponding temperatures. Laboratory No. 23 reported extension to the nearest 0.00005 in. while Laboratory No. 15 reported extensions measured to the nearest 0.000006 in., yet Laboratory No. 23, using the less sensitive extensometer, reported the lower values for the proportional limits.

This would indicate that any advantage gained by the use of more sensitive measuring instruments will only be realized if other important factors entering into the problem of reproducible high temperature tension tests are also under control.

Additional data are needed concerning rates of loading, temperature control and other details of the methods and procedure employed by some of the cooperators to throw light upon the causes of the described differences. However, the differences illustrated in the appended charts clearly indicate that there are details of our present day test methods and apparatus that are not under sufficient control. More attention to these so as to procure more nearly standardized test methods and equipment and smaller deviations in the results reported on the same metals from different laboratories is much to be desired. The appended stress-strain curves clearly show the desirability of using more sensitive strain measuring devices for such work.

A further analysis of data is under way and the information needed to make a more complete study of results will be included with data for other steels in the next reports of the committee.

Respectfully submitted,

L. W. SPRING
CLAIR UPTHEGROVE
H. J. FRENCH, *Chairman,*
Sub-Committee on Analysis and
Corelation of Short-Time Tests.

APPENDIX II

REPORT ON THERMAL EXPANSION OF MATERIALS

INTRODUCTION

This report covers the determination of thermal expansion data on two specimens each of materials K1, K2, K3, K4 and K5, submitted to the investigator by the Joint Research Committee on the Effect of Temperature on the Properties of Metals, through Mr. H. J. French.

The specimens of materials K1, K2, K3 and K4 were received from the Bureau of Standards on March 29, 1927. Two specimens each were stamped K1, K2, K3, one specimen K4 and one K4A. All specimens were 5½ in. long, K1 being 1 in. round, K2 being 1 in. round, K3 being 1⅛ in. round, and K4 being ¾ in. round.

TABLE I.—CHEMICAL COMPOSITION OF MATERIAL.

Mark	Carbon, per cent	Manganese, per cent	Phosphorus, per cent	Sulfur, per cent	Silicon, per cent	Chromium, per cent	Molybdenum, per cent	Iron, per cent	Nickel, per cent	Copper, per cent	Aluminum, per cent	Rolled to
K1[a]	0.17	0.42	0.012	0.035	....	....	....	....	....	....	....	1 in. round
K2	Stainless Steel to be analyzed by one of the cooperators											1 in. round
K3[a]	0.39	0.51	0.015	0.029	0.19	0.87	0.21	....	....	....	....	1⅛ in. round
K4[a]	0.31	2.79	....	....	0.27	18.8	....	0.80	76.0	0.66	....	¾ in. round
K5*A*	0.12	nil	trace	nil	0.047	....	....	0.37	99.40[b]	0.051	nil	Cold rolled to 1 × 1 in.
K5*B*	0.14	nil	trace	nil	0.056	....	....	0.32	99.45[b]	0.010	nil	Cold rolled to 1 × 1 in.

[a] Analyzed by manufacturer of the alloy.
[b] Nickel and Cobalt.

The two specimens of materials K5 were taken, one from each of two bars of 1-in. square cold-drawn and annealed material, received from the Bureau of Standards on May 16, 1927, the bars being intended for high-temperature tests. The bars were stamped "A" and "B" for identification.

The chemical analyses of the materials are given in Table I.

METHOD OF MAKING TESTS

All ten specimens were prepared for test and tested in the condition as received, that is, without further heat treatment of any kind. Specimens were machined to the dimensions and shape shown in Fig. 1.

The tests were conducted at the Westinghouse Research Laboratory by Mr. L. W. Schad, who has furnished the data and calculations embodied in this report.

The specimens were supported in an electric tube furnace built to give uniform temperature in the heating chamber. The temperatures were determined with a Leeds & Northrup type "K" potentiometer and copper-advance thermocouples. The thermocouples were carefully calibrated and are correct to within 0.2° C. up to 350° C., and 0.5° C., from 350 to 500° C. The hot junction of the couple made contact with the sample. Over each end of the specimen a tungsten wire one mil in diameter was dropped through a small slit in the furnace. To the lower end of each of these wires was attached a 40-g. weight which hung in oil to prevent swinging. The wires moved away from or toward each other, according to the amount of expansion or contraction of the sample and this movement was measured by micrometer microscopes sighted on the wires approximately 3 in. below the furnace.

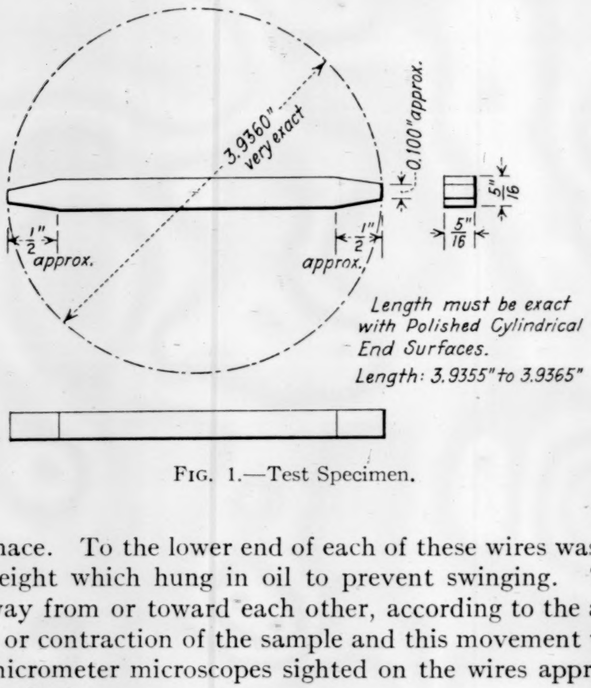
3.9360" very exact
0.100" approx.
5/16"
5/16"
1/2" approx.
1/2" approx.
Length must be exact with Polished Cylindrical End Surfaces.
Length: 3.9355" to 3.9365"

FIG. 1.—Test Specimen.

RESULTS OF TESTS

Expansion was determined on all ten specimens over a range of 0 to 500° C. The observed values are given in Table II in the order in which the observations were made, that is, up to 500° C. and then down to room temperature. In the case of K1, K2, K3 and K4, the letter *A* after the figure, as K1*A*, distinguishes in the table, one sample from the other of like material. A distinguishing mark was also placed on the sample for further reference. In the case of K5, the letters *A* and *B* were used, respectively, to distinguish one sample from the other.

TABLE II.—DETERMINATION OF EXPANSION OVER A RANGE OF 0 TO 500° C.

Sample	Temperature, deg. Cent.	Length Change, per Unit Length	Sample	Temperature, deg. Cent.	Length Change per Unit Length
K1	27	310×10^{-6}	K1*A*	22	253×10^{-6}
	141	1700		148	1823
	265	3380		266	3420
	396	5380		388	5283
	527	7530		516	7400
	350	4640		344	4613
	27	370		210	2640
				24	283
K2	27	270×10^{-6}			
	148	1550	K2*A*	25	242×10^{-6}
	265	2890		165	1700
	388	4420		282	3040
	518	6170		386	4340
	346	3880		515	6090
	204	2180		329	3640
	24	230		24	202
K3	25	261×10^{-6}	K3*A*	25	274×10^{-6}
	148	1640		149	1744
	268	3260		266	3264
	389	5020		388	5054
	522	7170		514	7054
	349	4480		345	4404
	215	2540		202	2374
	24	271		24	264
K4	25	300×10^{-6}	K4*A*	24	293
	143	1810		147	1813
	265	3540		264	3493
	388	5450		388	5393
	514	7580		514	7563
	350	4850		349	4803
	192	2490		197	2523
	24	210		24	233
K5*A*	25	316×10^{-6}	K5*B*	25	326×10^{-6}
	147	1956		146	1906
	264	3696		264	3656
	383	5661		387	5696
	509	7756		515	7800
	285	4036		242	3296
	25	356		25	326

The results are also given by plotting length change *versus* temperature from the observed values, and these are given in Figs. 2 to 11. In addition, an expansion equation obtained by geometrical and mathematical approximation, and a table of average and instantaneous coefficients are placed on each figure in the case of material K1, K2, K3 and K4. In the case of K5 material, only the average expansion coefficient is given.

In the expansion equation $L_t = L_o [1 + (at + bt^2) \times 10^{-6}]$, applying to the first four materials, L_t represents the length of a sample at t° C., where t is any temperature between 0 and 500° C.; L_o repre-

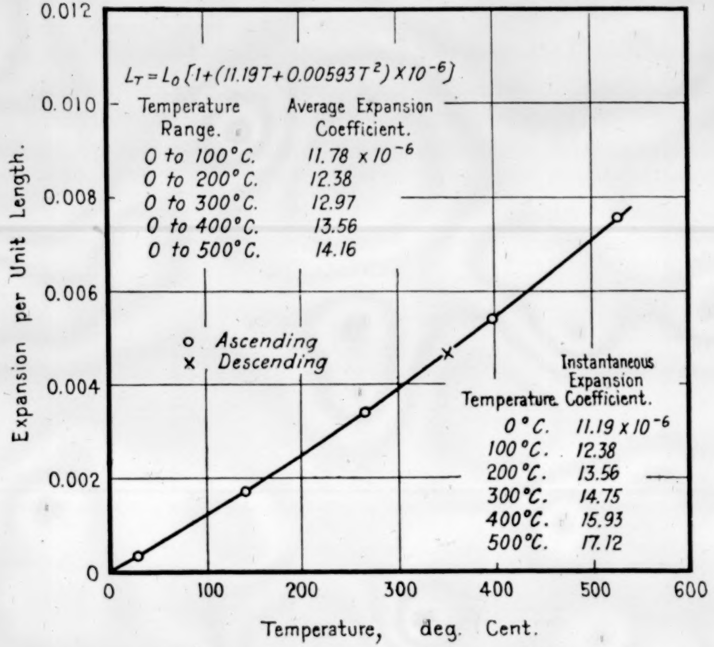

FIG. 2.—Thermal Expansion of K1 Material (0.17-per-cent Carbon Steel).

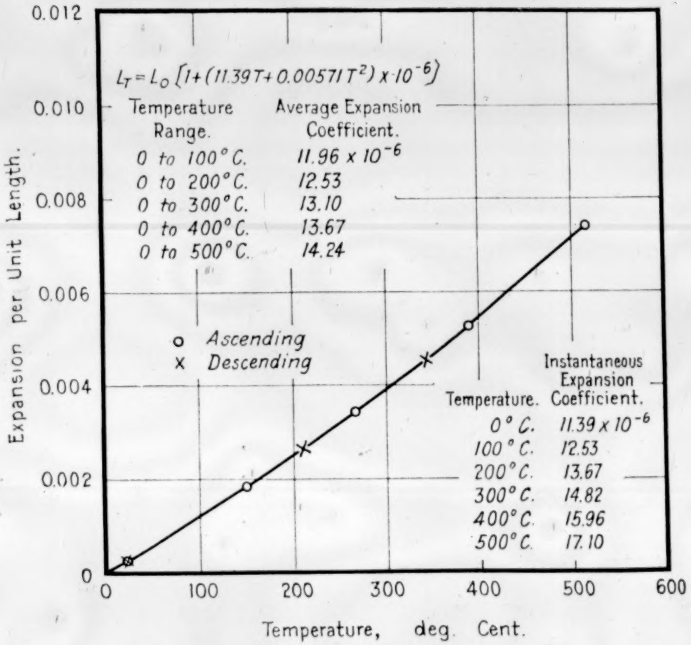

FIG. 3.—Thermal Expansion of K1*A* Material (0.17-per-cent Carbon Steel).

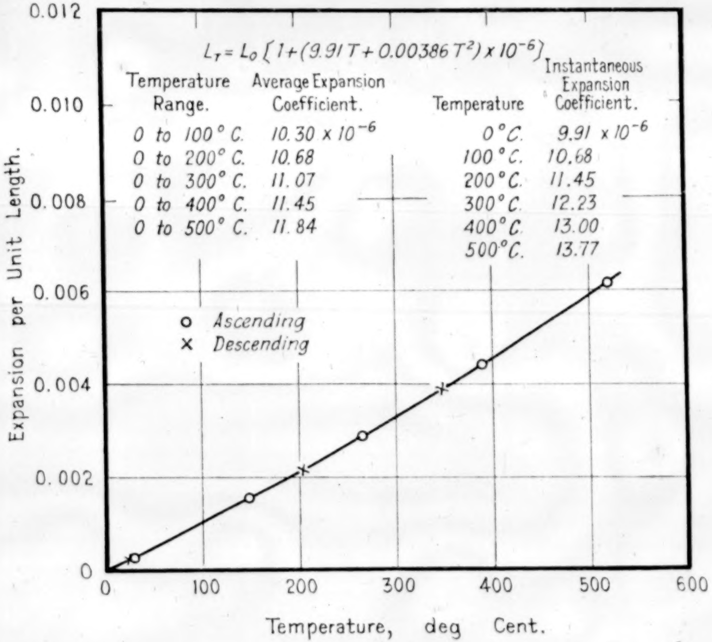

FIG. 4.—Thermal Expansion of K2 Material (Stainless Steel).

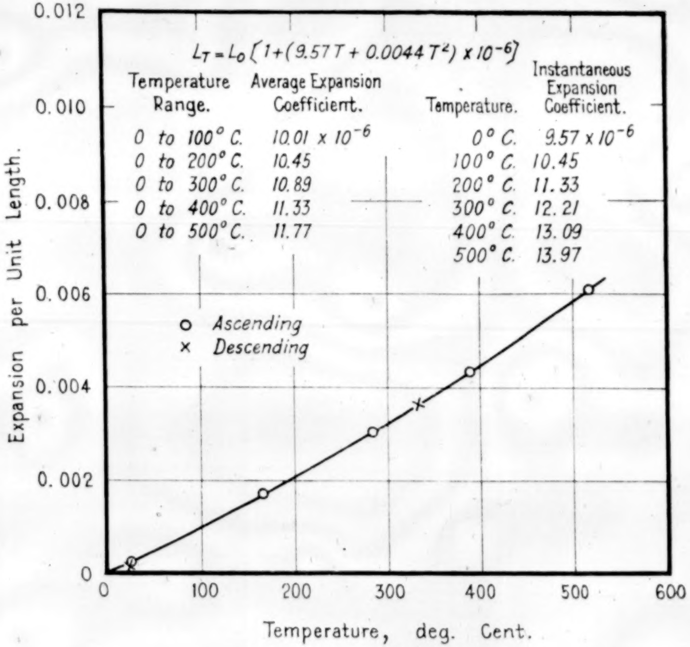

FIG. 5.—Thermal Expansion of K2A Material (Stainless Steel).

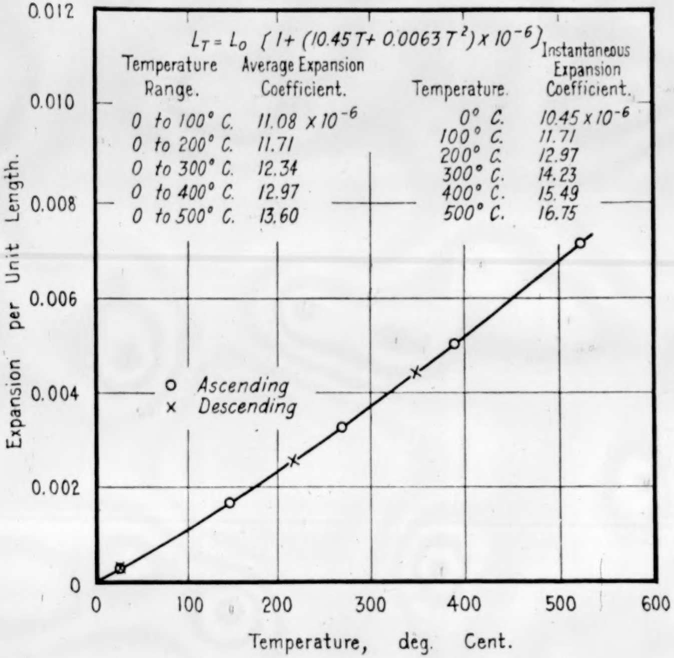

FIG. 6.—Thermal Expansion of K3 Material (Chrome-Molybdenum Steel).

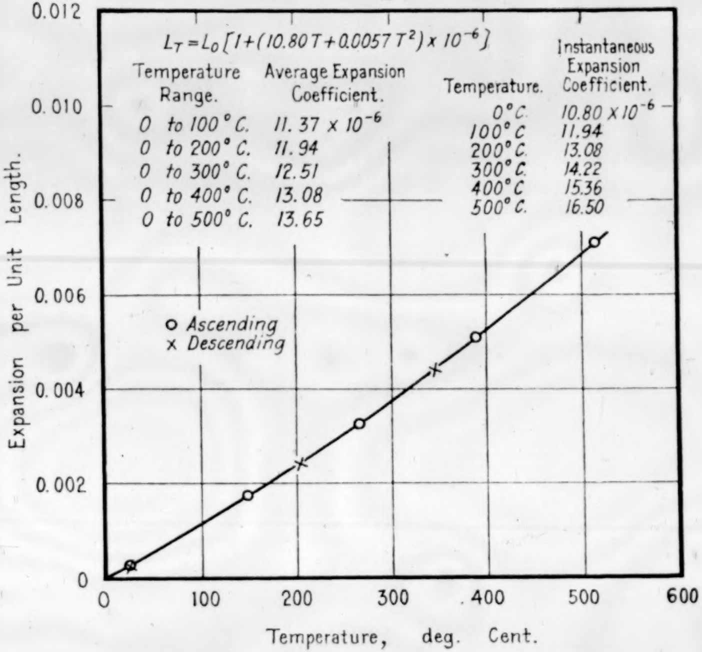

FIG. 7.—Thermal Expansion of K3*A* Material (Chrome-Molybdenum Steel).

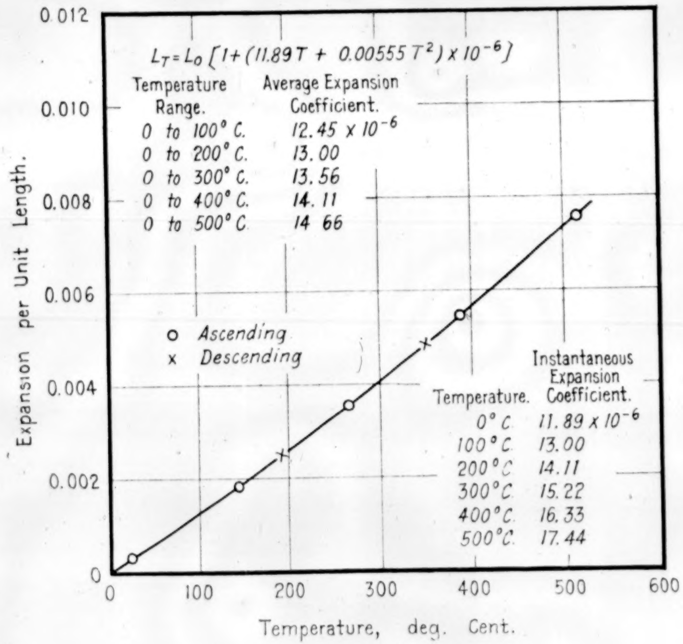

Fig. 8.—Thermal Expansion of K4 Material (Nichrome).

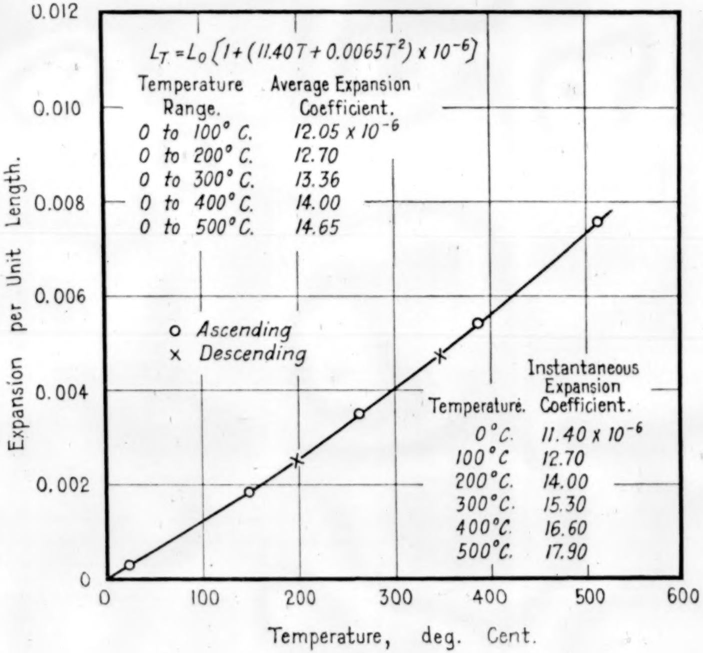

Fig. 9.—Thermal Expansion of K4*A* Material (Nichrome).

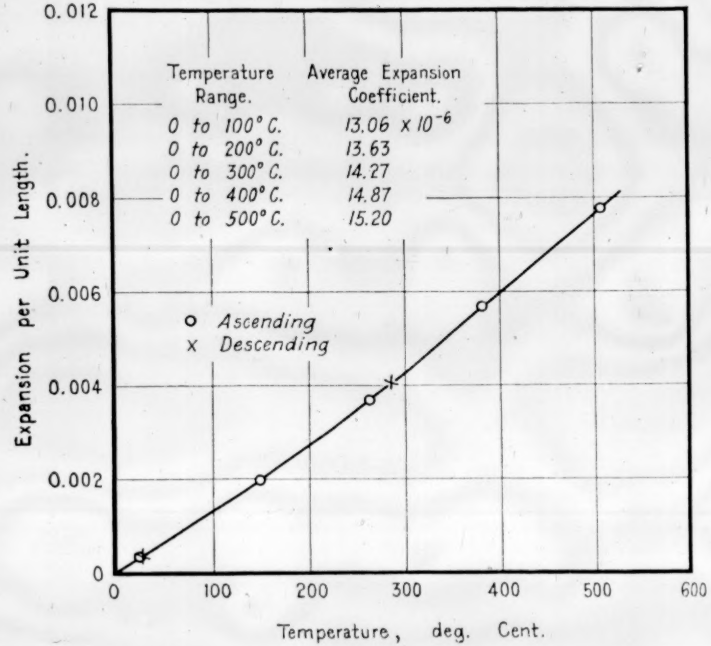

FIG. 10.—Thermal Expansion of K5*A* Material (Malleable Nickel).

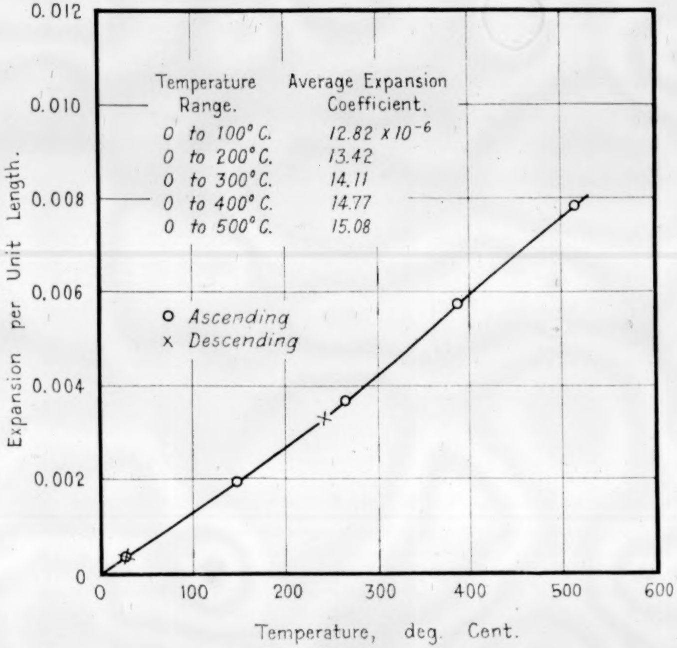

FIG. 11.—Thermal Expansion of K5*B* Material (Malleable Nickel).

sents the length of the sample at 0° C.; a and b are constants which are determined by the expansion of the material. From this equation, $\frac{L_t - L_o}{L_o}$ = expansion per unit length from 0 to t° C. = $(at + bt^2) \times 10^{-6}$ and the average coefficient of expansion is $\frac{L_t - L_o}{L_o t} = (a + bt) \times 10^{-6}$.

The instantaneous coefficient of expansion at any temperature t° C. is derived as follows:

Let the unit expansion or $\frac{L_t - L_o}{L_o} = y = (at + bt^2) \times 10^{-6}$, then $\frac{dy}{dt} = (a + 2\,bt) \times 10^{-6}$ is the slope of the expansion curve at any temperature t and is therefore the instantaneous coefficient at that temperature.

From the character of the expansion curves for K5 material, it is quite obvious that the length change can not be accurately expressed as a quadratic function of the temperature. Perhaps the most accurate relation between expansion and temperature might be expressed by an equation of the form

$$\frac{L_t - L_o}{L_o} = at + bt^2 + ct^3.$$

where a, b and c are constants to be determined from the observed data. Since there was some question of the desirability of retaining the equations when simply quadratic, it is hardly desirable to use the more complicated equations which would be necessary for the malleable nickel samples. Hence, the length-temperature equations and instantaneous expansion coefficients (which are derived from the equations) are omitted from Figs. 10 and 11. The average expansion coefficients were derived by using an approximate quadratic equation and deviations plotted on a large scale, of observed minus computed values *versus* temperatures.

ACCURACY OF RESULTS

The fine tungsten wires make an excellent target on which to sight with the micrometer microscopes. Readings may be repeated to within two divisions of the micrometer drum, which is approximately 1.5 microns (1 micron = 0.001 mm. or approximately 0.00004 in.). Assuming both microscope settings to be in error by 1.5 microns, the total error is 3 microns and the maximum deviation becomes ±3 microns.

All of the observations made on the expansion of each sample have been averaged by computing the length-change - temperature curve, which best fits all the observed points. However, this curve will not exactly fit, and the observed values minus the computed values constitute the deviations. For a specimen that has no irregularities such as internal stresses or transformation regions within the temperature range considered, the maximum deviation is ordinarily about ±3 microns which for a sample 10 cm. long is ±30 millionths per unit length. The average and maximum deviations for each sample show how accurately the length equation fits the observations. Table III gives these deviations for each sample of material with the exception of K5 material.

TABLE III.—AVERAGE AND MAXIMUM DEVIATIONS FOR EACH SAMPLE.

Sample	Average Deviation per Unit Length	Maximum Deviation per Unit Length
K1	±0.000005	+0.000020 at 396° C.
K1*A*	±0.000006	−0.000011 at 266° C.
K2	±0.000002	+0.000006 at 148° C.
K2*A*	±0.000006	+0.000012 at 515° C.
K3	±0.000013	−0.000047 at 148° C.
K3*A*	±0.000006	−0.000014 at 266° C.
K4	±0.000004	+0.000011 at 514° C.
K4*A*	±0.000016	+0.000030 at 264° C.

The length equations for some of the duplicate samples differ slightly from each other. It will be noted, however, that where the *a* term is larger, the *b* is smaller. Superimposing the curves of duplicate samples shows very little difference in expansion between them.

Computing the length changes from the equations in the case of samples K3 and K3*A* for example, we have 1709×10^{-6} and 1748×10^{-6}, respectively, at 150° C., and these values differ from each other by a little more than 2 per cent.

Respectfully submitted,

N. L. MOCHEL

REPORT OF COMMITTEE A-2

ON

WROUGHT IRON

During the past year Committee A-2 has held one meeting, on January 12, 1927. A second meeting will be held prior to the presentation of this report to the Society, at which the report will be reviewed and other matters considered.

RECOMMENDATIONS AFFECTING STANDARDS AND TENTATIVE STANDARDS

The recommendations of the committee affecting standards and tentative standards are presented first in summarized form, together with an analysis of the letter ballot on each item. They are then referred to, where necessary, in detail, being grouped for convenience in the order of the respective sub-committees responsible for them.

I. Proposed Revisions in Standards.—The committee recommends that the revisions in the following standards be referred to letter ballot of the Society for adoption as standard. The revisions are divided into two groups:

A. Revisions proposed at the 1925 and 1926 annual meetings and now presented for adoption by letter ballot of the Society.

B. Revisions now proposed for the first time, which the committee recommends be referred to letter ballot of the Society, by the necessary nine-tenths vote of the annual meeting.

The standard specifications in each group are as follows:

GROUP A

Revisions Presented in 1925[1] *and 1926*[2] *and now Recommended for Adoption Without Amendment.*

For Lap-Welded and Seamless Steel and Lap-Welded Iron Boiler Tubes (A 83 - 24);
For Welded Wrought-Iron Pipe (A 72 - 24);[3]
For Staybolt, Engine-Bolt and Extra-Refined Wrought-Iron Bars (A 84 - 24);
For Merchant Bar Iron (A 85 - 24);
Definitions of Terms Relating to Wrought-Iron Specifications (A 81 - 21).

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 25, Part I, p. 77 (1925).

[2] *Proceedings*, Am. Soc. Testing Mats., Vol. 26, Part I, p. 118 (1926).

[3] The proposed revisions of Sections 1 and 3 were withdrawn by the committee.—ED.

GROUP B

Revisions Proposed for First Time and Recommended for Adoption.

No. 1.—Standard Specification for Welded Wrought-Iron Pipe (A 72 – 24).[1]

Tables I and II.—Change from their present form by the elimination of the requirements for the following sizes:

4½, 7, 9 and 11-in. nominal sizes.

II. Proposed Revisions in Tentative Standards.—The committee recommends that the revisions in the following tentative standard be approved and that the specifications as amended be advanced to standard:

No. 2.—Tentative Specifications for Hollow Staybolt Iron (A 86 – 25 T).[2]

Title.—Change by the addition of the word "Rolled," to read as follows:

"Specifications for Hollow *Rolled* Staybolt Iron."

The above recommendations have been referred to letter ballot of the committee, which consists of 66 members; 53 ballots have been cast; 13 members have refrained from voting. The analysis of the vote of the committee is given below:

Items	Affirmative	Negative	Not[a] Voting
I. PROPOSED REVISIONS IN STANDARDS			
1. For Welded Wrought-Iron Pipe (A 72 – 24)	25	15	13
II. TENTATIVE SPECIFICATIONS ADVANCED TO STANDARD			
2. For Hollow Staybolt Iron (A 86 – 25 T), as revised	46	0	7
III. TENTATIVE REVISIONS OF STANDARDS ADVANCED TO STANDARD			
3. For Lap-Welded and Seamless Steel and Lap-Welded Iron Boiler Tubes (A 83 – 24)	40	3	10
4. For Welded Wrought-Iron Pipe (A 72 – 24)	25	15	13
5. For Staybolt, Engine-Bolt and Extra-Refined Wrought-Iron Bars (A 84 – 24)	46	2	5
6. For Merchant Bar Iron (A 85 – 24)	46	1	6
7. Definitions of Terms Relating to Wrought-Iron Specifications (A 81 – 21)	47	1	5

[a] In this column is recorded the number of votes cast as "Not Voting" on the various items.

Total number of ballots cast	53
Number of members who failed to vote	13
Total membership	66

In the following, the committee presents the foregoing recommendations in detail where necessary in the order of the respective sub-committees responsible for them:

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[1] 1924 Book of A.S.T.M. Standards.

[2] *Proceedings*, Am. Soc. Testing Mats., Vol. 25, Part I, p. 534 (1925); also 1926 Book of A.S.T.M. Tentative Standards, p. 100.

Sub-Committee I on Tubes and Pipe

The sub-committee is recommending the elimination of certain sizes of pipe from Specifications A 72 – 24. This action is in line with a simplification of pipe sizes recommended by a General Conference held at the Department of Commerce in May, 1926.

Sub-Committee III on Staybolt and Engine-Bolt Iron

This sub-committee has recommended changes in the Tentative Specifications for Hollow Staybolt Iron (A 86 – 25 T) to bring them into agreement with the similar specification of the American Railway Association.

At the January meeting the following resolution was passed:

TO WHOM IT MAY CONCERN:

At a meeting of Committee A-2 of the American Society for Testing Materials held on January twelfth, nineteen hundred and twenty seven, the following resolution was unanimously adopted and ordered to be spread upon the Minutes of the Meeting:

Whereas: Committee A-2 on Wrought Iron has learned to-day of the loss of one of its members who through long and pleasant association has endeared himself to his fellows; and

Whereas: He has been recalled in the midst of his life's work and with a future of great promise before him; therefore be it

Resolved: That the members of Committee A-2 express in this manner, their deep sorrow at the death of W. Gordon Gibson and their sincere sympathy with those closest to him in life. And be it further

Resolved: that a copy of these Resolutions be transmitted to his family and a similar copy to his associates in the Flannery Bolt Co.

This report has been submitted to letter ballot of the committee, which consists of 66 members, of whom 39 have voted affirmatively, 3 negatively, and 24 have refrained from voting.

Respectfully submitted on behalf of the committee,

H. J. Force,
Chairman.

G. H. Woodroffe,
Secretary.

Editorial Note

The proposed revisions of the Standard Specifications for Welded Wrought-Iron Pipe, proposed for the first time in 1927, were approved at the annual meeting by a nine-tenths vote and subsequently adopted by letter ballot of the Society on September 1, 1927. The tentative revisions of the Standard Specifications for Welded Wrought-Iron Pipe were approved at the annual meeting with the exception of the revisions of Sections 1 and 3, which latter revisions were withdrawn by the committee. The revisions approved were subsequently adopted by letter ballot of the Society on September 1, 1927. The specifications as revised appear in the 1927 Book of A.S.T.M. Standards, Part I.

The tentative revisions of the Standard Specifications for Lap-Welded and Seamless Steel and Lap-Welded Iron Boiler Tubes; for Staybolt, Engine-Bolt and Extra-Refined Wrought-Iron Bars; for Merchant Bar Iron; and of the Definitions of Terms Relating to Wrought-Iron Specifications, were approved at the annual meeting and subsequently adopted by letter ballot of the Society on September 1, 1927. The specifications as revised appear in the 1927 Book of A.S.T.M. Standards, Part I.

The Tentative Specifications for Hollow Staybolt Iron were approved at the annual meeting and subsequently adopted by letter ballot of the Society on September 1, 1927. They appear in the 1927 Book of A.S.T.M. Standards, Part I.

REPORT OF COMMITTEE A-3

ON

CAST IRON

Since the 1926 annual meeting of the Society, Committee A-3 has held two meetings, one on September 29, 1926, during the Convention of the American Foundrymen's Association at Detroit, and the other at Philadelphia on March 16, 1927. A third meeting will be held prior to the presentation of this report to the Society, at which the report will be reviewed and other matters considered.

The present membership of the committee is 70, of which 42 are classed as non-producers and 28 as producers.

RECOMMENDATIONS AFFECTING STANDARDS

The recommendations of the committee affecting standards are presented first in summarized form, together with an analysis of the letter ballot on each item.

The committee recommends that the revisions in the following standards, which are given in full in the appendix to this report, be published as tentative for one year before referring them to letter ballot of the Society for adoption as standard:

Specifications for Gray-Iron Castings (A 48 - 18);
Specifications for Cast-Iron Soil Pipe and Fittings (A 74 - 18);
Specifications for High-Test Gray-Iron Castings (A 88 - 24).

It further recommends that the proposed revisions of the Standard Methods of Sampling and Chemical Analysis of Pig and Cast Iron (A 64 - 16), consisting of complete revised methods[1] be accepted to supersede immediately the present standard methods. The committee accordingly asks for the necessary nine-tenths vote.

The above recommendations have been referred to letter ballot of the committee, which consists of 70 members; 42 ballots were cast, 28 members having failed to vote. The analysis of the vote of the committee is given in Table I.

The committee adopted resolutions in memory of the late George K. Elliott and the late G. A. Drysdale, members of Committee A-3 who died during the past year.

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[1] See 1927 Book of A.S.T.M. Standards, Part I, p. 448.—Ed.

SUB-COMMITTEE ACTIVITIES

The membership of Sub-Committee III on Cylinders has been increased in order to make it into a more active group.

Sub-Committee VIII on Cast-Iron Soil Pipe and Fittings is working on tentative specifications for cast-iron culvert pipe which should be ready for submission in a few months.

Sub-Committee XII on Methods of Chemical Analysis has completed the work of drawing up tentative methods for the sampling and chemical analysis of pig and cast iron which are being recommended as a revision of the present standard methods. During the coming year the sub-committee plans to do some work dealing with the direct determination of combined carbon in cast iron.

Sub-Committee XIII on High-Test Cast Iron, the membership of which has been increased, has laid out a definite program of work to be followed out through the year. It is endeavoring to encourage the production of higher strength cast irons.

TABLE I.

Items	Affirmative	Negative	Not Voting
PROPOSED REVISIONS IN STANDARDS			
1. Specifications for Gray-Iron Castings (A 48 – 18)	30	2	10
2. Specifications for Cast-Iron Soil Pipe and Fittings (A 74 – 18)	31	1	10
3. Specifications for High-Test Gray-Iron Castings (A 88 – 24)	30	1	11
4. Methods of Sampling and Chemical Analysis of Pig and Cast Iron (A 64 – 16)	38	0	4

Sub-Committee XIV on Correlation of Test Bar and Casting reported that it is working with Sub-Committee XIII on this problem.

Sub-Committee XV on Impact Testing, was organized during the past year and an extensive program of work laid out.

CHANGES IN TEST BARS

For several years the committee has had under consideration a change in the arbitration test bar. It was felt that the standard bar was deficient in respect to values for deflection. Also, the standard bar did not conform with test bars used abroad. After considerable work and discussion, the committee has adopted a new tentative arbitration test bar. This bar comes closer to being an international standard and also appears to give better values for deflection of cast iron. The change in test bar necessitates changes in the following specifications:

For Gray-Iron Castings (A 48 – 18);
For Cast-Iron Soil Pipe and Fittings (A 74 – 18);
For High-Test Gray-Iron Castings (A 88 – 24).

The tension test specimen used in the Specifications for Gray-Iron Castings (A 48 – 18) was slightly different from the bar used in the Specifications for High-Test Gray-Iron Castings (A 88 – 24). Slight changes in the tension test specimen were made and the new specimen was approved for use in both specifications.

This report has been submitted to letter ballot of the committee, which consists of 74 members, of whom 42 have voted affirmatively, 2 negatively, and 30 have refrained from voting.

Respectfully submitted on behalf of the committee,

R. S. MACPHERRAN,
Chairman.

HYMAN BORNSTEIN,
Secretary.

EDITORIAL NOTE

The proposed revisions of the Standard Methods of Sampling and Chemical Analysis of Pig and Cast Iron were approved at the annual meeting by a nine-tenths vote and subsequently adopted by letter ballot of the Society on September 1, 1927. The methods as revised appear in the 1927 Book of A.S.T.M. Standards, Part I.

The proposed revisions of the Standard Specifications for Gray-Iron Castings; Cast-Iron Soil Pipe and Fittings; and for High-Test Gray-Iron Castings were accepted for publication as tentative and appear on pages 1089, 1090 and 1091, respectively.

APPENDIX

PROPOSED REVISIONS IN STANDARDS

No. 1. *Standard Specifications for Gray Iron Castings (A 48 - 18).*[1]—

Section 5. (a).—Change to read as follows by the addition of the italicized figures and the omission of those in brackets:

> "The transverse test specimens (arbitration test bars) specified in Section 7 (a), when placed horizontally upon supports [12] *18* in. apart and tested under a centrally applied load, shall conform to the following minimum requirements, interpreted in accordance with Section 9:

	Class of Casting		
	Light	Medium	Heavy
"Load at center, lb.............	[2500] *1500*	[2900] *1750*	[3300] *2000*
Deflection at center, in.........	[0.10] *0.20*	[0.10] *0.20*	[0.10] *0.20*"

Figure 1.—Change the present Fig. 1, showing the arbitration test bar, referred to in Section 8, to conform to the accompanying Fig. 1.

Figure 2.—Change the present Fig. 2, showing the tension test specimen, referred to in Section 11, to conform to the accompanying Fig. 2.

No. 2. *Standard Specifications for Cast-Iron Soil Pipe and Fittings (A 74 - 18).*[1]—

Section 4.—Change to read as follows by the addition of the italicized figures and the omission of those in brackets:

> "The transverse test specimens (arbitration test bars) specified in Section 7, when placed horizontally upon supports [12] *18* in. apart and tested under a centrally applied load, shall conform to the following minimum requirements:

"Average load at center, lb......................	[2500] *1500*
Average deflection at center, in..................	[0.10] *0.20*"

Figure 1.—Change the present Fig. 1, showing the arbitration test bar, referred to in Section 4, to conform to the accompanying Fig. 1.

---

[1] 1924 Book of A.S.T.M. Standards.

No. 3. *Standard Specifications for High-Test Gray-Iron Castings (A 88 – 24).*[1]—

Section 4 (a).—Change to read as follows by the addition of the italicized figures and the omission of those in brackets:

> "The transverse test specimens (arbitration test bars) specified in Section 6 (a), when placed horizontally upon supports [12] *18* in. apart and tested under a centrally applied load, shall withstand a minimum load of [3800] *2250* lb. and deflect under this load at least [0.12] *0.24* in. at the center."

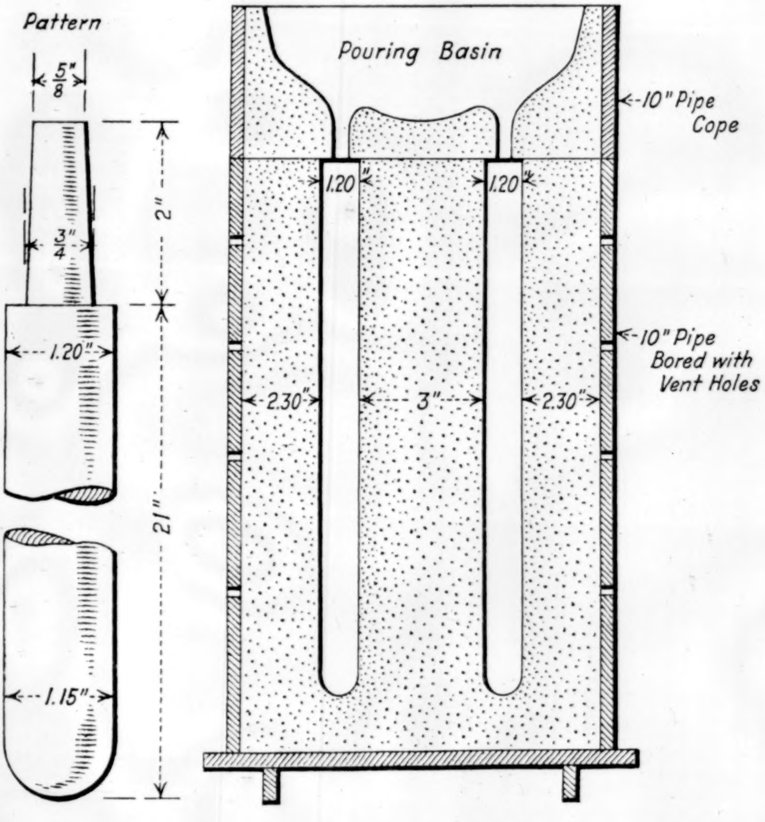
Pattern
5"/8
2"
3"/4
1.20"
21"
1.15"
Pouring Basin
10" Pipe Cope
1.20"
1.20"
10" Pipe Bored with Vent Holes
2.30"
3"
2.30"

FIG. 1.—Mold for Arbitration Test Bar.

Figure 1.—Change the present Fig. 1, showing the arbitration test bar, referred to in Section 6 (*a*), to conform to the accompanying Fig. 1.

---

[1] 1924 Book of A.S.T.M. Standards.

Figure 2.—Change the present Fig. 2, showing the tension test specimen, referred to in Section 6 (*b*), to conform to the accompanying Fig. 2.

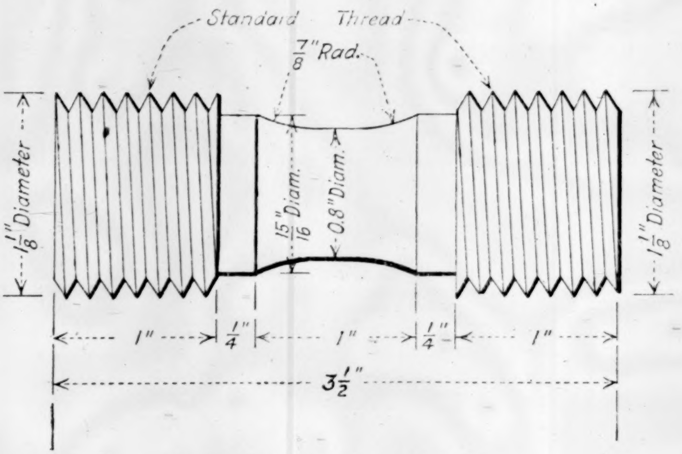
Standard Thread
7/8" Rad.
1 1/8" Diameter
15/16" Diam.
0.8" Diam.
1 1/8" Diameter
1"
1/4"
1"
1/4"
1"
3 1/2"

FIG. 2.—Tension Test Specimen.

No. 4. *Standard Methods of Sampling and Chemical Analysis of Pig and Cast Iron (A 64 – 16).*[1]—

These methods have been completely rewritten and are appended hereto[2] in their revised form to supersede immediately the present standard methods.

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[1] 1924 Book of A.S.T.M. Standards.

[2] See 1927 Book of A.S.T.M. Standards, Part I, p. 448.—ED.

REPORT OF COMMITTEE A-4
ON
HEAT TREATMENT OF IRON AND STEEL

The committee has held one meeting since the last annual meeting. This meeting was held at Washington, D. C., on January 20, 1927, and was called to consider two matters which are the basis for this report.

The committee recommends that the present Tentative Recommended Practice for Carburizing and Heat Treatment of Carburized Objects (A 37 - 25 T)[1] be advanced to standard, replacing the present Recommended Practice for the Heat Treatment of Case-Hardened Carbon-Steel Objects (A 37 - 14).[2]

This recommendation has been submitted to letter ballot of the committee, which consists of 42 members, of whom 32 members have voted affirmatively, none negatively, and 10 have refrained from voting.

At the Washington meeting, a report was received from the Joint Committee on Definitions of Terms Relating to Heat Treatment Operations. The personnel of the Joint Committee is as follows:

Representing the American Society for Testing Materials	John Howe Hall H. M. Boylston G. B. Waterhouse
Representing the Society of Automotive Engineers	George L. Norris Stanley P. Rockwell John A. Mathews
Representing the American Society for Steel Treating	J. Fletcher Harper W. J. Merten Bradley Stoughton
Secretary	J. Edward Donnellan

The report of the Joint Committee consisted of a number of proposed definitions of terms. These were amended slightly and are appended hereto[3] in their amended form. In transmitting the definitions, the Joint Committee submitted the following, indicating the basis on which the definitions were prepared:

---

[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 25, Part I, p. 568 (1925); also 1926 Book of A.S.T.M. Tentative Standards, p. 156.

[2] 1924 Book of A.S.T.M. Standards.

[3] See p. 703.—Ed.

> 1. During recent years certain confusion has arisen in regard to the meaning of commonly used heat treating terms. For instance, in one locality or trade, any operation of heating and cooling resulting in a softening of the material, is being called annealing, whereas in other places to "anneal" means not primarily "to soften" but to heat to above the critical temperature and cool very slowly. Similar confusion as to meaning and application exists in regard to other terms and as a result "annealing," "tempering," "normalizing," etc., are being used by different people, to mean widely different things.
>
> 2. In any attempt accurately to define the terms commonly used in connection with heat treatment, the first question to decide and the most important one is: Do the terms relate to the heat treatment operation itself, or to the results obtained by the treatment? In other words, is the term indicative of the structure or the condition obtained, or of the operation performed?
>
> 3. After careful consideration, it appears most logical and most in keeping with present day usage to have the terms so defined that they shall mean definite operations and shall not be considered as referring to the resultant structures or general conditions.

Committee A-4 recommends that the Definitions of Terms Relating to Heat Treatment Operations be accepted as Tentative Definitions of the Society.

This recommendation has been submitted to letter ballot of the committee, which consists of 42 members, of whom 30 have voted affirmatively, 3 negatively, and 9 have refrained from voting.

This report has been submitted to letter ballot of the committee, which consists of 42 members, of whom 39 have voted affirmatively, 2 negatively, and one has refrained from voting.

Respectfully submitted on behalf of the committee,

H. M. BOYLSTON,
Chairman.

J. H. HALL,
Secretary.

EDITORIAL NOTE

The Tentative Recommended Practice for Carburizing and Heat Treatment of Carburized Objects was approved at the annual meeting to supersede the present Recommended Practice for the Heat Treatment of Case-Hardened Carbon-Steel Objects and was subsequently adopted by letter ballot of the Society on September 1, 1927. The recommended practice appears in the 1927 Book of A.S.T.M. Standards, Part I.

The proposed Tentative Definitions of Terms Relating to Heat Treatment Operations were accepted for publication as tentative and appear on page 703.

REPORT OF COMMITTEE A-5

ON

CORROSION OF IRON AND STEEL

Committee A-5 has had a very busy year, and all of its subcommittees have shown marked enthusiasm and substantial progress in their work.

Sub-Committee III on Inspection of the Fort Sheridan and Annapolis Tests reports some additional failures and presents tables giving the results of the ten years exposures of the various sheets grouped as regarding the presence of copper. At Fort Sheridan the eight new failures during the year are equally divided between low-copper pure iron and copper-bearing pure iron, and at Annapolis the four new failures were equally divided between low-copper pure iron and low-copper open-hearth steel. At Annapolis 20 per cent of the non-copper-bearing light gage sheets have failed while none of the copper-bearing sheets have failed. It is also observed that the two groups of low-copper metals showing the greatest number of failures at Annapolis were the first groups to completely fail at both Pittsburgh and Fort Sheridan, which would indicate that the sheets failing at the three locations are failing in the same general order, the rate of failure being very rapid at Pittsburgh, less rapid at Fort Sheridan and comparatively slow at Annapolis.

Sub-Committee V on Total Immersion Tests has continued its inspections of the tests at Annapolis and Washington, these tests now nearing completion. The additional failures in the No. 16-gage sheets bear out previous findings which show that where the metals are submerged the presence of copper does not give increased resistance to corrosion. The additional tests on these original sheets to study their behavior when submerged in open ocean water are under way at Portsmouth, N. H., and Key West, Fla. The ship plate tests to determine the effect in salt water corrosion of fabricating together metals of unlike copper content, as well as the study of copper steel tubing in similar exposure, are now under way in cooperation with the U. S. Navy Department at Portsmouth, N. H., Key West, Fla., and Port Arthur, Tex., and the inspections during the coming year will no doubt give interesting information.

Sub-Committee VI on Specifications for Metallic-Coated Products has continued its study of wire and wire products and offers substantial revisions to the present specifications for the Coating on Zinc-Coated (Galvanized) Wire (A 110 - 26 T), for Zinc-Coated (Galvanized) Iron or Steel Telephone and Telegraph Line Wire (A 111 - 26 T), and for Zinc-Coated (Galvanized) Iron or Steel Tie Wires (A 112 - 26 T). Also new specifications are presented for Zinc-Coated (Galvanized) Wire Fencing, Zinc-Coated Chain-Link Fence Fabric Galvannized Before Weaving, and Zinc-Coated Chain-Link Fence Fabric Galvanized After Weaving. All of these specifications are recommended for acceptance for publication as tentative.[1] The Tentative Specifications for Hot-Dipped Galvanized Sheets (A 93 - 24 T) have been extensively revised as the result of comprehensive studies by a special group in the sub-committee. It is the feeling of the committee that the revised specifications as now presented represent the very best thought on quality requirements for galvanized sheets and the specifications are recommended for adoption as standard.

Specifications for strand and barbed wire are in the final stages of preparation, and the collection of information on sherardized coatings gives promise of early specifications for products of this kind. All of the revised tentative and new tentative specifications presented this year have been transmitted to the Sectional Committee on Zinc Coating for Iron and Steel.

Sub-Committee VII on Methods of Testing has been reorganized during the past year, the membership being now identical with that of Technical Committee VII (Methods of Testing) of the Sectional Committee on Zinc Coating, which arrangement will afford very satisfactory contacts for the correlation of methods of testing with field exposure tests. The work at this time is concerned primarily with zinc coatings, and the sub-committee is now actively at work along lines of investigation dealing with physical tests of coatings, quantitative analysis of coatings, uniformity of coatings and corrosion or accelerated weathering tests. The study of coatings other than zinc, particularly chromium, is under consideration. The enthusiasm and interest manifested by these groups in their programs bids fair to substantial accomplishments during the coming year.

Sub-Committee VIII on Field Tests of Metallic Coatings completed the installation of the galvanized sheet atmospheric tests in April and May of last year, and are presenting in their present report details of selection of test locations, the designs of the racks and enclosing fences, selection, inspection and fabrication of the test sheets, markings for identification and method of fastening specimens on the test racks. All of these features were worked out in a most painstaking and careful manner that would provide for ready identification and ease of inspection. In this connection it is a pleasure for the committee to record again its appreciation of the generous support it has had from cooperating companies without which it would have been impractical, if not impossible, to have undertaken these comprehensive tests. All of the tests have been inspected by the Sheet Inspection Committee within the year, and as might be anticipated none of the sheets have failed, the coatings in all cases being predominatingly metallic zinc. A certain amount of zinc alloy layer described as "chatter marks" was observed on some sheets; however, no rust spots were observed on any sheets. The crystallin appearance of the coating shows considerable variation from that of large spangles to that of a dull gray alloy, as illustrated by Fig. 12, a condition that will be followed with interest to determine if this variation in crystallin appearance has any bearing on service or fabrication of the sheets. The bend specimens were inspected at all locations; however, sufficient data are not available for any specific conclusions, other than the generally accepted one that, other conditions being the same, flaking is more pronounced as the weight of coating increases. The report carries a number of interesting illustrations and tables giving data for the sheets exposed at the five locations. The specimens for the accelerated tests as well as a large reserve stock have been carefully packed in soldered tin-lined cases and will be stored with the U. S. Bureau of Standards at Washington, D. C., for future use, anticipating that additional tests may be necessary in other locations in the country for the completion of this study.

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[1] See pp. 679–697.—ED.

During the year there has been one important extension of the committee's work in the corrosion field in the organization of a Sub-Committee on Metal Culvert Corrosion Tests with the following personnel:

James H. Gibboney, *Temporary Chairman,*
Norfolk and Western Railway Co.,
Roanoke, Va.

W. J. Beck, Director of Research,
American Rolling Mill Co.,
Middletown, Ohio.

W. R. Fleming, Metallurgical Engineer,
The Andrews Steel Co.,
Newport, Ky.

H. S. Mattimore, Engineer of Materials,
Pennsylvania State Highway Department,
Harrisburg, Pa.

O. H. Hansard, Engineer of Tests,
State Highway Department,
Nashville, Tenn.

J. T. Hay, Metallurgical Engineer,
Central Alloy Steel Corporation,
Massillon, Ohio.

B. P. Hazeltine, Research Engineer,
Wheeling Steel Corporation,
Wheeling, W. Va.

E. F. Kelley, Acting Chief,
Division of Tests, U. S. Bureau of Public Roads,
Washington, D. C.

W. C. Swartout, Senior Assistant Engineer,
Missouri Pacific Railway Co.,
St. Louis, Mo.

E. S. Taylerson, Engineer of Tests,
American Sheet and Tin Plate Co.,
Pittsburgh, Pa.

W. H. Woodbury, Valuation Engineer,
Duluth and Iron Range Railroad Co.,
Duluth, Minn.

This new sub-committee held its first meeting at Columbus, Ohio, on April 27, and after reviewing in a very general way some of the work that has already been done along the lines of service rating of metal culverts as an engineering material, it was decided that for the present the work would be confined to a study of the corrugated flexible metal culvert, having in mind that later on it may take up the study of the cast-iron culvert which is the only other type of culvert that falls under its jurisdiction. As a first step the sub-committee will seek to assemble the results of investigations that have already been made from a service standpoint as a material and not as a structure, the thought being that the future work would no doubt be directed along the lines of determining the suitability and comparative values of the different types of base metals used in flexible culvert construction and under varying soil and other service conditions. The line of approach for a comprehensive study of the bibliography of the flexible metal culvert as a material will be through a questionnaire which will be sent to state highway departments, railroads and other large consumers of this type of culvert, which might fairly develop what work has been accomplished, the methods of service rating and the interest and need for further tests.

The following is the result of the letter ballot of the committee on the recommendations made in this report:

Items	Affirm-ative	Neg-ative	Not Voting
I. TENTATIVE STANDARD ADVANCED TO STANDARD			
Tentative Specifications for Hot-Dipped Galvanized Sheets (A 93 - 24 T), as revised	54	0	13
II. PROPOSED REVISION OF TENTATIVE STANDARDS			
Tentative Specifications for the Coating on Zinc-Coated (Galvanized) Wire and Wire Products (A 110 - 26 T)	45	4	15
Tentative Specifications for Zinc-Coated (Galvanized) Iron or Steel Telephone and Telegraph Line Wire (A 111 - 26 T)	45	3	16
Tentative Specifications for Zinc-Coated (Galvanized) Iron or Steel Tie Wires (A 112 - 26 T)	45	3	16
III. PROPOSED NEW TENTATIVE STANDARDS			
Proposed Tentative Specifications for Zinc-Coated (Galvanized) Wire Fencing	40	5	19
Proposed Tentative Specifications for Zinc-Coated Chain Link Fence Fabric Galvanized After Weaving	41	3	20
Proposed Tentative Specifications for Zinc-Coated Chain Link Fence Fabric Galvanized Before Weaving	42	2	20

This report has been submitted to letter ballot of the committee, which consists of 102 members, of whom 65 have voted affirmatively, none negatively, and 37 have refrained from voting.

Respectfully submitted on behalf of the committee,

J. H. GIBBONEY,
Chairman.

JAMES ASTON,
Secretary.

EDITORIAL NOTE

The Tentative Specifications for Hot-Dipped Galvanized Sheets, as revised, were approved at the annual meeting and subsequently adopted as standard by letter ballot of the Society, on September 1, 1927. They appear in the 1927 Book of A.S.T.M. Standards, Part I.

The proposed revisions of the Tentative Specifications for the Coating on Zinc-Coated (Galvanized) Wire; for Zinc-Coated (Galvanized) Iron or Steel Telephone and Telegraph Line Wire; and for Zinc-Coated (Galvanized) Iron or Steel Tie Wires, were accepted. The tentative specifications as thus revised appear on pages 696, 679 and 684, respectively.

The proposed Tentative Specifications for Zinc-Coated (Galvanized) Wire Fencing; for Zinc-Coated Chain-Link Fence Fabric Galvanized After Weaving; and for Zinc-Coated Chain-Link Fence Fabric Galvanized Before Weaving, were accepted for publication as tentative. They appear on pages 687, 690 and 693, respectively.

REPORT OF SUB-COMMITTEE III ON INSPECTION OF THE FORT SHERIDAN AND ANNAPOLIS TESTS

Sub-Committee III on Inspection has held two meetings during the past year.

First Meeting

The first meeting was held at Fort Sheridan, Ill., on September 24, 1926, with Messrs. Brooks representing Beck, McDonnell, Smith, Taylerson and Major McLeany, representing the Quartermaster's Corps of the United States War Department, present; Messrs. Cooper, Fleming, Gibboney and the representative of the Bureau of Steam Engineering of the United States Navy Department being absent. The following additional failures were recorded:

Sheets D-16 and 18 (No. 22 Gage Low-Copper Pure Iron, Series A) failed due to cracks at lower portion of the sheets.

Sheet X-27 (No. 22 Gage Low-Copper Pure Iron, Series B) manufactured by the Inland Steel Co. This sheet failed due to a hole 12 in. from lower end.

The sheets at Annapolis, Md., were inspected on November 17, 1926, by Messrs. Cooper, Gibboney, McDonnell, Passano, representing Beck, Smith, Taylerson, Thompson, representing the Bureau of Steam Engineering of the United States Navy Department, and Wheaton; Mr. Fleming being absent. The following additional failures were recorded:

Sheet O-6 (No. 22 Gage Low-Copper Open-Hearth Steel, Series A) failed due to small holes at the bottom of the sheet.

Sheet O-11 (No. 22 Gage Low-Copper Open-Hearth Steel, Series A) failed due to ragged edge at the bottom of the sheet.

Sheet S-3 (No. 22 Gage Low-Copper Pure Iron, Series B) manufactured by the American Rolling Mill Co. This sheet failed due to a small hole and ragged edges at the bottom of the sheet.

No photographic record was made of the failed sheets at Fort Sheridan and Annapolis. The members of the sub-committee observed that very little change in the general characteristics of the sheets had taken place since the preceding inspection. No detail record covering the condition of the sheets at Fort Sheridan as regarding texture, color and adherence of rust was made due to heavy rains. However, this detail information, as well as certain data covering mechanical damage, was recorded at Annapolis and has been filed in the records of the sub-committee for any future reference.

TABLE I.—FAILURES AT FORT SHERIDAN TESTS. INSPECTI

Group	Designation	Series	Description	Average Analysis, per cent				
				Carbon	Man-ganese	Phos-phorus	Sulfur	Silico
EE	Puddled Iron	A	Copper-Bearing	0.035	0.03	0.119	0.018	0.12
HH	Copper-Bearing Basic Open-hearth Steel	A	" "	0.074	0.373	0.011	0.026	0.00
II	Copper-Bearing Bessemer Steel	A	" "	0.059	0.371	0.095	0.066	0.00
KK	Copper-Bearing Acid Open-hearth Steel	A	" "	0.108	0.433	0.085	0.043	0.00
CCC	Copper-Bearing Pure Iron	A	" "	0.023	0.026	0.005	0.028	0.00
TT	Copper-Bearing Steel, Newport Rolling Mill Co	B	" "	0.080	0.313	0.009	0.020	0.00
UU	Copper-Bearing Pure Iron, Allegheny Steel Co	B	" "	0.018	0.066	0.008	0.028	0.00
VV	Copper-Bearing Pure Iron, Whitaker-Glessner Co	B	" "	0.018	0.046	0.007	0.019	0.00
ZZ	Copper-Bearing Bessemer Steel, Youngstown Sheet and Tube Co	B	" "	0.08	0.40	0.091	0.035	0.00
ZZ	Copper-Bearing Bessemer Steel Youngstown Sheet and Tube Co	B	" "	0.08	0.34	0.094	0.037	....
ZZ	Copper-Bearing Bessemer Steel Youngstown Sheet and Tube Co	B	" "	0.07	0.36	0.082	0.033	....
ZZ	Copper-Bearing Open-hearth Steel, Youngstown Sheet and Tube Co	B	" "	0.06	0.37	0.050	0.052	....
ZZ	Copper-Bearing Open-hearth Steel, Youngstown Sheet and Tube Co	B	" "	0.09	0.34	0.038	0.077	0.00
ZZ	Copper-Bearing Open-hearth Steel, Youngstown Sheet and Tube Co	B	" "	0.06	0.39	0.049	0.044	....
	Total	.....	.....	.....	.....	.....	.....	....
AA	Bessemer Steel	A	Non-Copper-Bearing	0.043	0.419	0.083	0.042	0.00
BB	Open-hearth Steel	A	" " "	0.056	0.349	0.022	0.048	0.03
CC	Copper-Bearing Pure Iron	A	" " "	0.019	0.029	0.004	0.032	0.00
DD	Low-Copper Pure Iron	A	" " "	0.019	0.028	0.004	0.027	0.00
OO	Low-Copper Open-hearth Steel	A	" " "	0.108	0.371	0.009	0.029	0.00
MM	Open-hearth Steel, Alan Wood Iron and Steel Co	B	" " "	0.017	0.414	0.010	0.029	0.00
SS	Low-Copper Pure Iron, American Rolling Mill Co	B	" " "	0.017	0.021	0.006	0.021	0.00
XX	Low-Copper Pure Iron, Inland Steel Co	B	" " "	0.021	0.062	0.008	0.030	0.00
YY	Low-Copper Wrought Iron, Youngstown Sheet and Tube Co	B	" " "	0.03	0.051	0.123	0.019	0.20
ZZ	Bessemer Steel, Youngstown Sheet and Tube Co	B	" " "	0.08	0.45	0.102	0.037	0.00
ZZ	Open-hearth Steel, Youngstown Sheet and Tube Co	B	" " "	0.022	0.39	0.040	0.028	....
	Total	.....	.....	.....	.....	.....	.....	....
B	Open-hearth Steel	A	Copper-Bearing	0.06	0.27	0.014	0.053	0.00
C	Copper-Bearing Pure Iron	A	" "	0.015	0.028	0.006	0.036	0.00
E	Puddled Iron	A	" "	0.033	0.034	0.114	0.021	0.13
H	Copper-Bearing Basic Open-hearth Steel	A	" "	0.069	0.387	0.016	0.027	0.00
I	Copper-Bearing Bessemer Steel	A	" "	0.041	0.365	0.097	0.068	0.00
K	Copper-Bearing Acid Open-hearth Steel	A	" "	0.107	0.447	0.091	0.046	0.00
M	Open-hearth Steel, Al an Wood Iron and Steel Co	B	" "	0.093	0.419	0.013	0.041	0.01
T	Copper-Bearing Steel, Newport Rolling Mill Co	B	" "	0.083	0.313	0.009	0.020	0.00
U	Copper-Bearing Pure Iron, Allegheny Steel Co	B	" "	0.017	0.074	0.008	0.037	0.00
V	Copper-Bearing Pure Iron, Whitaker-Glessner Co	B	" "	0.018	0.051	0.007	0.021	0.00
Z	Copper-Bearing Bessemer Steel, Youngstown Sheet and Tube Co	B	" "	0.06	0.37	0.094	0.038	0.00
Z	Copper-Bearing Bessemer Steel, Youngstown Sheet and Tube Co	B	" "	0.05	0.37	0.114	0.048	....
Z	Copper-Bearing Open-hearth Steel, Youngstown Sheet and Tube Co	B	" "	0.06	0.35	0.049	0.059	....
Z	Copper-Bearing Open-hearth Steel, Youngstown Sheet and Tube Co	B	" "	0.06	0.39	0.047	0.047	....
Z	Copper-Bearing Open-hearth Steel, Youngstown Sheet and Tube Co	B	" "	0.07	0.41	0.042	0.042	....
	Total	.....	.....	.....	.....	.....	.....	....
A	Bessemer Steel	A	Non-Copper-Bearing	0.038	0.386	0.089	0.040	0.00
B	Open-hearth Steel	A	" " "	0.09	0.38	0.017	0.062	0.03
C	Copper-Bearing Pure Iron	A	" " "	0.01	0.028	0.002	0.027	0.00
D	Low-Copper Pure Iron	A	" " "	0.02	0.026	0.004	0.022	0.00
O	Low-Copper Open-hearth Steel	A	" " "	0.121	0.536	0.008	0.030	0.24
S	Low-Copper Pure Iron, American Rolling Mill Co	B	" " "	0.02	0.023	0.006	0.022	0.00
X	Low-Copper Pure Iron, Inland Steel Co	B	" " "	0.021	0.055	0.007	0.031	0.00
Y	Low-Copper Wrought Iron, Youngstown Sheet and Tube Co	B	" " "	0.03	0.055	0.139	0.021	0.21
Z	Bessemer Steel, Youngstown Sheet and Tube Co	B	" " "	0.07	0.44	0.107	0.046	0.00
Z	Bessemer Steel, Youngstown Sheet and Tube Co	B	" " "	0.06	0.38	0.077	0.035	0.00
Z	Open-hearth Steel, Youngstown Sheet and Tube Co	B	" " "	0.06	0.32	0.065	0.044	0.00
	Total	.....	.....	.....	.....	.....	.....	....

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[1] In preparing this table, sheets below 0.15 per cent copper have been considered as non-copper-bearing, and those above 0.15 per cent copper as copper-

[2] No failures were recorded at inspections made prior to March 31, 1919; the detail records are accordingly not given here.

PECTIONS OF 1917, 1918, 1919, 1920, 1921, 1922, 1923, 1924, 1925, 1926, AND MARCH, 1927. SHEETS EXPOSED APRIL 9, 19

r cent		Number of Sheets in Test	Date of Inspec								
Silicon	Copper		Mar. 31, 1919.[a] 24 Months	Dec. 6, 1919. 32 Months	May 10, 1920. 37 Months	Oct. 11, 1920 42 Months	Apr. 4, 1921. 48 Months	Oct. 17, 1921 54 Months	Apr. 10, 1922. 60 Months	Oct. 16, 1922. 66 Months	Mar. 8, 19 71 Month
			No. 16 GAGE SHEETS								
0.125	0.319	12	None	None	None	None	None	None	None	None	None
0.004	0.237	17	None	None	None	None	None	None	None	None	None
0.006	0.247	19	None	None	None	None	None	None	None	None	None
0.005	0.234	19	None	None	None	None	None	None	None	None	None
0.005	0.236	12	None	None	None	None	None	None	None	None	None
0.006	0.223	14	None	None	None	None	None	None	None	None	None
0.005	0.239	13	None	None	None	None	None	None	None	None	None
0.004	0.299	19	None	None	None	None	None	None	None	None	None
0.006	0.154	1	None	None	None	None	None	None	None	None	None
.....	0.279	2	None	None	None	None	None	None	None	None	None
.....	0.528	2	None	None	None	None	None	None	None	None	None
.....	0.172	2	None	None	None	None	None	None	None	None	None
0.003	0.641	2	None	None	None	None	None	None	None	None	None
.....	0.318	2	None	None	None	None	None	None	None	None	None
.....	.....	136	None	None	None	None	None	None	None	None	None
0.004	0.012	17	None	None	None	None	None	13 (1)	None	None	None
0.037	0.129	17	None	None	None	None	None	None	None	None	None
0.003	0.067	12	None	None	None	None	None	None	None	None	None
0.004	0.028	19	None	None	None	None	None	None	None	None	None
0.007	0.029	12	None	None	None	None	None	None	None	None	None
0.007	0.057	14	None	None	None	None	None	None	None	None	None
0.006	0.025	12	None	None	None	None	None	None	None	None	None
0.005	0.028	14	None	None	None	None	None	None	None	None	None
0.203	0.023	3	None	None	None	None	None	None	None	None	None
0.008	0.014	2	None	None	None	None	None	None	None	None	None
.....	0.030	2	None	None	None	None	None	None	None	None	None
.....	.....	124	None	None	None	None	None	1	None	None	None
			No. 22 GAGE SHEETS								
0.006	0.156	2	None	None	None	None	None	None	None	None	None
0.003	0.195	10	None	None	None	None	None	None	None	None	None
0.134	0.283	12	None	None	None	None	None	None	None	None	None
0.004	0.244	11	None	None	None	None	None	None	None	None	None
0.008	0.252	19	None	None	None	None	None	None	None	None	None
0.004	0.237	16	None	None	None	None	None	None	None	None	None
0.011	0.185	14	None	None	None	None	None	None	None	None	None
0.005	0.227	14	None	None	None	None	None	None	None	None	None
0.005	0.260	14	None	None	None	None	None	None	None	None	None
0.005	0.304	14	None	None	None	None	None	None	None	None	None
0.007	0.263	2	None	None	None	None	None	None	None	None	None
.....	0.533	2	None	None	None	None	None	None	None	None	None
.....	0.212	2	None	None	None	None	None	None	None	None	None
.....	0.286	2	None	None	None	None	None	None	None	None	None
.....	0.532	2	None	None	None	None	None	None	None	None	None
.....	.....	136	None	None	None	None	None	None	None	None	None
0.007	0.014	15	None	None	16, 17, 18 (3)	None	19, 29, 30, (3)	None	None	22 (1)	None
0.036	0.103	11	None	None	None	None	None	None	None	None	None
0.002	0.144	2	None	None	None	None	None	None	None	None	None
0.002	0.024	6	None	None	None	None	None	None	None	22 (1)	None
0.249	0.020	12	None	14, 15, 21 (3)	13, 16, 19, 23, 24 (5)	17, 18, 20, 22 (4)	....	....	....	....	....
0.004	0.022	14	None	None	None	None	None	16, 22, 25, 26, 28 (5)	17, 18, 19, 20, 21 23, 24, 27 (8)	15 (1)	....
0.004	0.027	14	None	None	None	None	25 (1)	None	None	15, 17 (2)	None
0.218	0.020	3	None	None	None	4 (1)	None	None	None	None	None
0.003	0.011	2	None	None	None	None	4, 5 (2)		....	....	....
0.009	0.130	2	None	None	None	None	None	None	None	None	None
0.002	0.018	2	None	None	421 (1)	None	None	420 (1)	....	....	....
.....	.....	83	None	3	9	5	6	6	8	5	None

copper-bearing.

REPORT OF SUB-COMMITTEE III ON INSPECTION OF THE FORT SHERIDAN AND ANNAPOLIS TESTS

Sub-Committee III on Inspection has held two meetings during the past year.

FIRST MEETING

The first meeting was held at Fort Sheridan, Ill., on September 24, 1926, with Messrs. Brooks representing Beck, McDonnell, Smith, Taylerson and Major McLeany, representing the Quartermaster's Corps of the United States War Department, present; Messrs. Cooper, Fleming, Gibboney and the representative of the Bureau of Steam Engineering of the United States Navy Department being absent. The following additional failures were recorded:

Sheets D-16 and 18 (No. 22 Gage Low-Copper Pure Iron, Series A) failed due to cracks at lower portion of the sheets.

Sheet X-27 (No. 22 Gage Low-Copper Pure Iron, Series B) manufactured by the Inland Steel Co. This sheet failed due to a hole 12 in. from lower end.

The sheets at Annapolis, Md., were inspected on November 17, 1926, by Messrs. Cooper, Gibboney, McDonnell, Passano, representing Beck, Smith, Taylerson, Thompson, representing the Bureau of Steam Engineering of the United States Navy Department, and Wheaton; Mr. Fleming being absent. The following additional failures were recorded:

Sheet O-6 (No. 22 Gage Low-Copper Open-Hearth Steel, Series A) failed due to small holes at the bottom of the sheet.

Sheet O-11 (No. 22 Gage Low-Copper Open-Hearth Steel, Series A) failed due to ragged edge at the bottom of the sheet.

Sheet S-3 (No. 22 Gage Low-Copper Pure Iron, Series B) manufactured by the American Rolling Mill Co. This sheet failed due to a small hole and ragged edges at the bottom of the sheet.

No photographic record was made of the failed sheets at Fort Sheridan and Annapolis. The members of the sub-committee observed that very little change in the general characteristics of the sheets had taken place since the preceding inspection. No detail record covering the condition of the sheets at Fort Sheridan as regarding texture, color and adherence of rust was made due to heavy rains. However, this detail information, as well as certain data covering mechanical damage, was recorded at Annapolis and has been filed in the records of the sub-committee for any future reference.

TABLE I.—FAILURES AT FORT SHERIDAN TESTS. INSPECTIONS OF 1917, 1918, 1919, 1920, 1921, 1922, 1923,

Group	Designation	Series	Description	Average Analysis, per cent						Number of Sheets in Test			
				Carbon	Manganese	Phosphorus	Sulfur	Silicon	Copper		Mar. 31, 1919.[a] 24 Months	Dec. 6, 1919. 32 Months	May 10, 1920. 37 Months
EE	Puddled Iron	A	Copper-Bearing	0.035	0.03	0.119	0.018	0.125	0.319	12	None	None	None
HH	Copper-Bearing Basic Open-hearth Steel	A	" "	0.074	0.373	0.011	0.026	0.004	0.237	17	None	None	None
II	Copper-Bearing Bessemer Steel	A	" "	0.059	0.371	0.095	0.066	0.006	0.247	19	None	None	None
KK	Copper-Bearing Acid Open-hearth Steel	A	" "	0.108	0.433	0.085	0.043	0.005	0.234	19	None	None	None
CCC	Copper-Bearing Pure Iron	A	" "	0.023	0.026	0.005	0.028	0.005	0.236	12	None	None	None
TT	Copper-Bearing Steel, Newport Rolling Mill Co	B	" "	0.080	0.313	0.009	0.020	0.006	0.223	14	None	None	None
UU	Copper-Bearing Pure Iron, Allegheny Steel Co	B	" "	0.018	0.066	0.008	0.028	0.005	0.239	13	None	None	None
VV	Copper-Bearing Pure Iron, Whitaker-Glessner Co	B	" "	0.018	0.046	0.007	0.019	0.004	0.299	19	None	None	None
ZZ	Copper-Bearing Bessemer Steel, Youngstown Sheet and Tube Co	B	" "	0.08	0.40	0.091	0.035	0.006	0.154	1	None	None	None
ZZ	Copper-Bearing Bessemer Steel Youngstown Sheet and Tube Co	B	" "	0.08	0.34	0.094	0.037	.....	0.279	2	None	None	None
ZZ	Copper-Bearing Bessemer Steel Youngstown Sheet and Tube Co	B	" "	0.07	0.36	0.082	0.033	.....	0.528	2	None	None	None
ZZ	Copper-Bearing Open-hearth Steel, Youngstown Sheet and Tube Co	B	" "	0.06	0.37	0.050	0.052	.....	0.172	2	None	None	None
ZZ	Copper-Bearing Open-hearth Steel, Youngstown Sheet and Tube Co	B	" "	0.09	0.34	0.038	0.077	0.003	0.641	2	None	None	None
ZZ	Copper-Bearing Open-hearth Steel, Youngstown Sheet and Tube Co	B	" "	0.06	0.39	0.049	0.044	.....	0.318	2	None	None	None
	Total			.....	.....	.....	.....	.....	.....	136	None	None	None
AA	Bessemer Steel	A	Non-Copper-Bearing	0.043	0.419	0.083	0.042	0.004	0.012	17	None	None	None
BB	Open-hearth Steel	A	" " "	0.056	0.349	0.022	0.048	0.037	0.129	17	None	None	None
CC	Copper-Bearing Pure Iron	A	" " "	0.019	0.029	0.004	0.032	0.003	0.067	12	None	None	None
DD	Low-Copper Pure Iron	A	" " "	0.019	0.028	0.004	0.027	0.004	0.028	19	None	None	None
OO	Low-Copper Open-hearth Steel	A	" " "	0.108	0.371	0.009	0.029	0.007	0.029	12	None	None	None
MM	Open-hearth Steel, Alan Wood Iron and Steel Co	B	" " "	0.017	0.414	0.010	0.029	0.007	0.057	14	None	None	None
SS	Low-Copper Pure Iron, American Rolling Mill Co	B	" " "	0.017	0.021	0.006	0.021	0.006	0.025	12	None	None	None
XX	Low-Copper Pure Iron, Inland Steel Co	B	" " "	0.021	0.062	0.008	0.030	0.005	0.028	14	None	None	None
YY	Low-Copper Wrought Iron, Youngstown Sheet and Tube Co	B	" " "	0.03	0.051	0.123	0.019	0.203	0.023	3	None	None	None
ZZ	Bessemer Steel, Youngstown Sheet and Tube Co	B	" " "	0.08	0.45	0.102	0.037	0.008	0.014	2	None	None	None
ZZ	Open-hearth Steel, Youngstown Sheet and Tube Co	B	" " "	0.022	0.39	0.040	0.028	.....	0.030	2	None	None	None
	Total			.....	.....	.....	.....	.....	.....	124	None	None	None
B	Open-hearth Steel	A	Copper-Bearing	0.06	0.27	0.014	0.053	0.006	0.156	2	None	None	None
C	Copper-Bearing Pure Iron	A	" "	0.015	0.028	0.006	0.036	0.003	0.195	10	None	None	None
E	Puddled Iron	A	" "	0.033	0.034	0.114	0.021	0.134	0.283	12	None	None	None
H	Copper-Bearing Basic Open-hearth Steel	A	" "	0.069	0.387	0.016	0.027	0.004	0.244	11	None	None	None
I	Copper-Bearing Bessemer Steel	A	" "	0.041	0.365	0.097	0.068	0.008	0.252	19	None	None	None
K	Copper-Bearing Acid Open-hearth Steel	A	" "	0.107	0.447	0.091	0.046	0.004	0.237	16	None	None	None
M	Open-hearth Steel, Alan Wood Iron and Steel Co	B	" "	0.093	0.419	0.013	0.041	0.011	0.185	14	None	None	None
T	Copper-Bearing Steel, Newport Rolling Mill Co	B	" "	0.083	0.313	0.009	0.020	0.005	0.227	14	None	None	None
U	Copper-Bearing Pure Iron, Allegheny Steel Co	B	" "	0.017	0.074	0.008	0.037	0.005	0.260	14	None	None	None
V	Copper-Bearing Pure Iron, Whitaker-Glessner Co	B	" "	0.018	0.051	0.007	0.021	0.005	0.304	14	None	None	None
Z	Copper-Bearing Bessemer Steel, Youngstown Sheet and Tube Co	B	" "	0.06	0.37	0.094	0.038	0.007	0.263	2	None	None	None
Z	Copper-Bearing Bessemer Steel, Youngstown Sheet and Tube Co	B	" "	0.05	0.37	0.114	0.048	.....	0.533	2	None	None	None
Z	Copper-Bearing Open-hearth Steel, Youngstown Sheet and Tube Co	B	" "	0.06	0.35	0.049	0.059	.....	0.212	2	None	None	None
Z	Copper-Bearing Open-hearth Steel, Youngstown Sheet and Tube Co	B	" "	0.06	0.39	0.047	0.047	.....	0.286	2	None	None	None
Z	Copper-Bearing Open-hearth Steel, Youngstown Sheet and Tube Co	B	" "	0.07	0.41	0.042	0.042	.....	0.532	2	None	None	None
	Total			.....	.....	.....	.....	.....	.....	136	None	None	None
A	Bessemer Steel	A	Non-Copper-Bearing	0.038	0.386	0.089	0.040	0.007	0.014	15	None	None	16, 17, 18 (3)
B	Open-hearth Steel	A	" " "	0.09	0.38	0.017	0.062	0.036	0.103	11	None	None	None
C	Copper-Bearing Pure Iron	A	" " "	0.01	0.028	0.002	0.027	0.002	0.144	2	None	None	None
D	Low-Copper Pure Iron	A	" " "	0.02	0.026	0.004	0.022	0.002	0.024	6	None	None	None
O	Low-Copper Open-hearth Steel	A	" " "	0.121	0.536	0.008	0.030	0.249	0.020	12	None	14, 15, 21 (3)	13, 16, 19, 23, 24 (5)
S	Low-Copper Pure Iron, American Rolling Mill Co	B	" " "	0.02	0.023	0.006	0.022	0.004	0.022	14	None	None	None
X	Low-Copper Pure Iron, Inland Steel Co	B	" " "	0.021	0.055	0.007	0.031	0.004	0.027	14	None	None	None
Y	Low-Copper Wrought Iron, Youngstown Sheet and Tube Co	B	" " "	0.03	0.055	0.139	0.021	0.218	0.020	3	None	None	None
Z	Bessemer Steel, Youngstown Sheet and Tube Co	B	" " "	0.07	0.44	0.107	0.046	0.003	0.011	2	None	None	None
Z	Bessemer Steel, Youngstown Sheet and Tube Co	B	" " "	0.06	0.38	0.077	0.035	0.009	0.130	2	None	None	None
Z	Open-hearth Steel, Youngstown Sheet and Tube Co	B	" " "	0.06	0.32	0.065	0.044	0.002	0.018	2	None	None	421 (1)
	Total			.....	.....	.....	.....	.....	.....	83	None	3	9

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[1] In preparing this table, sheets below 0.15 per cent copper have been considered as non-copper-bearing, and those above 0.15 per cent copper as copper-bearing.

[a] No failures were recorded at inspections made prior to March 31, 1919; the detail records are accordingly not given here.

PLATE I.
PROC. AM. SOC. TESTING MATS.
VOL. 27, PART I.
REPORT OF COMMITTEE A-5:
CORROSION TESTS.

923, 1924, 1925, 1926, AND MARCH, 1927. SHEETS EXPOSED APRIL 9, 1917. COMPARING COPPER-BEARING WITH NON-COPPER-BEARING MATERIALS.[1]

Date of Inspection																Number of Sheets Failed in Test
. 1920. onths	Oct. 11, 1920 42 Months	Apr. 4, 1921. 48 Months	Oct. 17, 1921 54 Months	Apr. 10, 1922. 60 Months	Oct. 16, 1922. 66 Months	Mar. 8, 1923. 71 Months	Oct. 12, 1923. 78 Months	Apr. 16, 1924. 84 Months	Oct. 12, 1924. 90 Months	Mar. 11, 1925 95 Months	Sept. 18, 1925. 101 Months	Apr. 8, 1926. 108 Months	Sept. 24, 1926. 113 Months	Mar. 28, 1927. 119 Months	
No. 16 GAGE SHEETS																
one	None	None	None	None	None	None	None	None	None	None	None	None	None	None	None
one	None	None	None	None	None	None	None	None	None	None	None	None	None	None	None
one	None	None	None	None	None	None	None	None	None	None	None	None	None	None	None
one	None	None	None	None	None	None	None	None	None	None	None	None	None	None	None
one	None	None	None	None	None	None	None	None	None	None	None	None	None	None	None
one	None	None	None	None	None	None	None	None	None	None	None	None	None	None	None
one	None	None	None	None	None	None	None	None	None	None	None	None	None	None	None
one	None	None	None	None	None	None	None	None	None	None	None	None	None	None	None
one	None	None	None	None	None	None	None	None	None	None	None	None	None	None	None
one	None	None	None	None	None	None	None	None	None	None	None	None	None	None	None
one	None	None	None	None	None	None	None	None	None	None	None	None	None	None	None
one	None	None	None	None	None	None	None	None	None	None	None	None	None	None	None
ne	None	None	None	None	None	None	None	None	None	None	None	None	None	None	None
one	None	None	None	None	None	None	None	None	None	None	None	None	None	None	None
ne	None	None	None	None	None	None	None	None	None	None	None	None	None	None	None
ne	None	None	13 (1)	None	None	None	None	None	None	None	11 (1)	None	None	None	2
ne	None	None	None	None	None	None	None	None	None	None	None	None	None	None	None
ne	None	None	None	None	None	None	None	None	None	None	None	None	None	None	None
ne	None	None	None	None	None	None	None	None	None	None	None	None	None	None	None
ne	None	None	None	None	None	None	None	None	None	None	None	None	None	None	None
ne	None	None	None	None	None	None	None	None	None	None	None	None	None	None	None
ne	None	None	None	None	None	None	None	None	None	None	None	None	None	None	None
ne	None	None	None	None	None	None	None	None	None	None	None	None	None	None	None
ne	None	None	None	None	None	None	None	None	None	None	None	None	None	None	None
ne	None	None	None	None	None	None	None	None	None	None	None	None	None	None	None
ne	None	None	None	None	None	None	None	None	None	None	None	None	None	None	None
ne	None	None	1	None	None	None	None	None	None	None	1	None	None	None	2
No. 22 GAGE SHEETS																
ne	None	None	None	None	None	None	None	None	None	None	None	None	None	None	None
ne	None	None	None	None	None	None	None	None	None	None	6 (1)	None	None	8 (1)	2
ne	None	None	None	None	None	None	None	None	None	None	13 (1)	None	None	None	1
ne	None	None	None	None	None	None	None	None	None	None	None	None	None	None	None
ne	None	None	None	None	None	None	None	None	None	None	None	None	None	None	None
ne	None	None	None	None	None	None	None	None	None	None	None	None	None	None	None
ne	None	None	None	None	None	None	None	None	None	None	None	None	None	None	None
ne	None	None	None	None	None	None	None	None	None	None	None	None	None	None	None
ne	None	None	None	None	None	None	None	None	None	None	None	None	None	16, 19, 21 (3)	3
ne	None	None	None	None	None	None	None	None	None	None	None	None	None	None	None
ne	None	None	None	None	None	None	None	None	None	None	None	None	None	None	None
ne	None	None	None	None	None	None	None	None	None	None	None	None	None	None	None
ne	None	None	None	None	None	None	None	None	None	None	None	None	None	None	None
ne	None	None	None	None	None	None	None	None	None	None	None	None	None	None	None
ne	None	None	None	None	None	None	None	None	None	None	None	None	None	None	None
ne	None	None	None	None	None	None	None	None	None	None	2	None	None	4	6
18 (3)	None	19, 29, 30, (3)	None	None	22 (1)	None	25 (1)	21 (1)	None	None	20, 23, 24, 26, 28 (5)	None	None	None	14
ne	None	None	None	None	None	None	None	None	None	None	None	None	None	None	None
ne	None	None	None	None	None	None	None	None	None	None	None	None	None	None	None
ne	None	None	None	None	22 (1)	None	None	None	None	None	None	None	16, 18 (2)	None	3
, 23, 24)	17, 18, 20, 22 (4)	....	....	....	....	....	....	....	....	....	....	....	....	....	12 (all)
ne	None	None	16, 22, 25, 26, 28 (5)	17, 18, 19, 20, 21 23, 24, 27 (8)	15 (1)	....	....	....	....	....	....	....	....	....	14 (all)
ne	None	25 (1)	None	None	15, 17 (2)	None	None	None	None	16 (1)	22, 23 (2)	24, 26, 28 (3)	27 (1)	20 (1)	11
ne	4 (1)	None	None	None	None	None	6 (1)	None	None	None	5 (1)	....	....	....	3 (all)
ne	None	4, 5 (2)	....	....	....	....	....	....	....	....	....	....	....	....	2 (all)
ne	None	None	None	None	None	None	None	None	None	None	None	None	None	None	None
(1)	None	None	420 (1)	....	....	....	....	....	....	....	....	....	....	....	2 (all)
	5	6	6	8	5	None	2	1	None	1	8	3	3	1	61

TABLE II.—FAILURES AT ANNAPOLIS TESTS. INSPECTIONS OF 1917, 1918, 191
COMPARING COPPER-BEA

Group	Designation	Series	Description	Average analysis, per cent					
				Carbon	Manganese	Phosphorus	Sulfur	Silicon	Copper
	No. 16 G								
EE	Puddled Iron	A	Copper-Bearing	0.035	0.03	0.119	0.018	0.125	0.319
HH	Copper-Bearing Basic Open-hearth Steel	A	" "	0.074	0.373	0.011	0.026	0.004	0.237
II	Copper-Bearing Bessemer Steel	A	" "	0.059	0.371	0.095	0.066	0.006	0.247
KK	Copper-Bearing Acid Open-hearth Steel	A	" "	0.108	0.433	0.085	0.043	0.005	0.234
CCC	Copper-Bearing Pure Iron	A	" "	0.023	0.026	0.005	0.028	0.005	0.236
TT	Copper-Bearing Steel, Newport Rolling Mill Co	B	" "	0.080	0.313	0.009	0.020	0.006	0.223
UU	Copper-Bearing Pure Iron, Allegheny Steel Co	B	" "	0.018	0.066	0.008	0.028	0.005	0.239
VV	Copper-Bearing Pure Iron, Whitaker-Glessner Co	B	" "	0.018	0.046	0.007	0.019	0.004	0.299
ZZ	Copper-Bearing Bessemer Steel, Youngstown Sheet and Tube Co	B	" "	0.113	0.413	0.109	0.045	.....	0.167
ZZ	Copper-Bearing Bessemer Steel, Youngstown Sheet and Tube Co	B	" "	0.080	0.34	0.091	0.036	.....	0.293
ZZ	Copper-Bearing Bessemer Steel, Youngstown Sheet and Tube Co	B	" "	0.073	0.305	0.089	0.045	None	0.532
ZZ	Copper-Bearing Open-hearth Steel, Youngstown Sheet and Tube Co	B	" "	0.074	0.39	0.069	0.072	.....	0.255
ZZ	Copper-Bearing Open-hearth Steel, Youngstown Sheet and Tube Co	B	" "	0.077	0.363	0.057	0.080	0.002	0.652
ZZ	Copper-Bearing Open-hearth Steel, Youngstown Sheet and Tube Co	B	" "	0.06	0.42	0.050	0.048	Trace	0.363
	Total	.....	.....	.....	.....	.....	.....	.....	.....
AA	Bessemer Steel	A	Non-Copper-Bearing	0.043	0.419	0.083	0.042	0.004	0.012
BB	Open-hearth Steel	A	" " "	0.056	0.349	0.022	0.018	0.037	0.113
CC	Copper-Bearing Pure Iron	A	" " "	0.019	0.029	0.004	0.032	0.003	0.067
DD	Low-Copper Pure Iron	A	" " "	0.019	0.028	0.004	0.027	0.004	0.028
OO	Low-Copper Open-hearth Steel	A	" " "	0.108	0.371	0.009	0.029	0.007	0.029
MM	Open-hearth Steel, Alan Wood Iron and Steel Co	B	" " "	0.017	0.414	0.010	0.029	0.007	0.057
SS	Low-Copper Pure Iron, American Rolling Mill Co	B	" " "	0.017	0.021	0.006	0.021	0.006	0.025
XX	Low-Copper Pure Iron, Inland Steel Co	B	" " "	0.021	0.062	0.008	0.030	0.005	0.028
YY	Low-Copper Wrought Iron, Youngstown Sheet and Tube Co	B	" " "	0.03	0.051	0.123	0.019	0.203	0.023
ZZ	Bessemer Steel, Youngstown Sheet and Tube Co	B	" " "	0.08	0.43	0.080	0.031	0.008	0.014
ZZ	Open-hearth Steel, Youngstown Sheet and Tube Co	B	" " "	0.047	0.389	0.040	0.027	0.007	0.033
	Total	.....	.....	.....	.....	.....	.....	.....	.....
	No. 22 GAG								
B	Open-hearth Steel	A	Copper-Bearing	0.06	0.27	0.014	0.053	0.006	0.187
C	Copper-Bearing Pure Iron	A	" "	0.015	0.028	0.006	0.036	0.003	0.194
E	Puddled Iron	A	" "	0.033	0.034	0.114	0.021	0.134	0.283
H	Copper-Bearing Basic Open-hearth Steel	A	" "	0.069	0.387	0.016	0.027	0.004	0.244
I	Copper-Bearing Bessemer Steel	A	" "	0.041	0.365	0.097	0.068	0.008	0.252
K	Copper-Bearing Acid Open-hearth Steel	A	" "	0.107	0.447	0.091	0.046	0.004	0.237
M	Open-hearth Steel, Alan Wood Iron and Steel Co	B	" "	0.093	0.419	0.013	0.041	0.011	0.185
T	Copper-Bearing Steel, Newport Rolling Mill Co	B	" "	0.083	0.313	0.009	0.020	0.005	0.227
U	Copper-Bearing Pure Iron, Allegheny Steel Co	B	" "	0.017	0.074	0.008	0.037	0.005	0.260
V	Copper-Bearing Pure Iron, Whitaker-Glessner Co	B	" "	0.018	0.051	0.007	0.021	0.005	0.304
Z	Copper-Bearing Bessemer Steel, Youngstown Sheet and Tube Co	B	" "	0.058	0.37	0.093	0.043	0.009	0.269
Z	Copper-Bearing Bessemer Steel, Youngstown Sheet and Tube Co	B	" "	0.055	0.38	0.110	0.046	.....	0.527
Z	Copper-Bearing Open-hearth Steel, Youngstown Sheet and Tube Co	B	" "	0.067	0.351	0.045	0.052	0.003	0.187
Z	Copper-Bearing Open-hearth Steel, Youngstown Sheet and Tube Co	B	" "	0.065	0.35	0.050	0.059	0.003	0.264
Z	Copper-Bearing Open-hearth Steel, Youngstown Sheet and Tube Co	B	" "	0.073	0.42	0.052	0.054	Trace	0.641
	Total	.....	.....	.....	.....	.....	.....	.....	.....
A	Bessemer Steel	A	Non-Copper-Bearing	0.038	0.386	0.089	0.040	0.007	0.014
B	Open-hearth Steel	A	" " "	0.09	0.38	0.017	0.062	0.036	0.084
C	Copper-Bearing Pure Iron	A	" " "	0.01	0.028	0.002	0.027	0.002	0.141
D	Low-Copper Pure Iron	A	" " "	0.02	0.026	0.004	0.022	0.002	0.024
O	Low-Copper Open-hearth Steel	A	" " "	0.121	0.536	0.008	0.030	0.249	0.020
S	Low-Copper Pure Iron, American Rolling Mill Co	B	" " "	0.02	0.023	0.006	0.022	0.004	0.022
X	Low-Copper Pure Iron, Inland Steel Co	B	" " "	0.021	0.055	0.007	0.031	0.004	0.027
Y	Low-Copper Wrought Iron, Youngstown Sheet and Tube Co	B	" " "	0.03	0.055	0.139	0.021	0.218	0.020
Z	Bessemer Steel, Youngstown Sheet and Tube Co	B	" " "	0.063	0.41	0.102	0.044	0.009	0.013
Z	Bessemer Steel, Youngstown Sheet and Tube Co	B	" " "	0.077	0.44	0.095	0.036	0.003	0.140
Z	Open-hearth Steel, Youngstown Sheet and Tube Co	B	" " "	0.032	0.32	0.063	0.042	.....	0.019
	Total	.....	.....	.....	.....	.....	.....	.....	.....

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[1] In preparing this table, sheets below 0.15 per cent copper have been considered as non-copper-bearing, and those above 0.15 per cent copper as copper-bearing.

[a] No failures were recorded at inspections made prior to March 5, 1923; the detail records are accordingly not given here.

Plate II.
Proc. Am. Soc. Testing Mats.
Vol. 27. Part I.
Report of Committee A-5:
Corrosion Tests.

, 1919, 1920, 1921, 1922, 1923, 1924, 1925, 1926, and March, 1927. Sheets Exposed October 17, 1916.
r-Bearing with Non-Copper-Bearing Materials.[1]

opper	Number of Sheets in Test	Date of Inspection									Number of Sheets Failed in Test
		Mar. 5, 1923.[a] 77 Months	Oct. 10, 1923. 84 Months	Apr. 18, 1924. 90 Months	Oct. 23, 1924. 96 Months	Mar. 27, 1925. 101 Months	Oct. 10, 1925. 108 Months	Mar. 29, 1926. 113 Months	Nov. 17, 1926. 121 Months	Mar. 21, 1927. 125 Months	
. 16 Gage Sheets											
.319	12	None	None	None	None	None	None	None	None	None	None
.237	16	None	None	None	None	None	None	None	None	None	None
.247	16	None	None	None	None	None	None	None	None	None	None
.234	18	None	None	None	None	None	None	None	None	None	None
.236	12	None	None	None	None	None	None	None	None	None	None
.223	14	None	None	None	None	None	None	None	None	None	None
.239	14	None	None	None	None	None	None	None	None	None	None
.299	14	None	None	None	None	None	None	None	None	None	None
.167	2	None	None	None	None	None	None	None	None	None	None
.293	3	None	None	None	None	None	None	None	None	None	None
.532	2	None	None	None	None	None	None	None	None	None	None
.255	3	None	None	None	None	None	None	None	None	None	None
.652	2	None	None	None	None	None	None	None	None	None	None
.363	2	None	None	None	None	None	None	None	None	None	None
....	130	None	None	None	None	None	None	None	None	None	None
.012	18	None	None	None	None	None	None	None	None	None	None
.113	17	None	None	None	None	None	None	None	None	None	None
.067	12	None	None	None	None	None	None	None	None	None	None
.028	19	None	None	None	None	None	None	None	None	None	None
.029	12	None	None	None	None	None	None	None	None	None	None
.057	14	None	None	None	None	None	None	None	None	None	None
.025	14	None	None	None	None	None	None	None	None	None	None
.028	14	None	None	None	None	None	None	None	None	None	None
.023	3	None	None	None	None	None	None	None	None	None	None
.014	3	None	None	None	None	None	None	None	None	None	None
.033	3	None	None	None	None	None	None	None	None	None	None
....	129	None	None	None	None	None	None	None	None	None	None
22 Gage Sheets											
.187	9	None	None	None	None	None	None	None	None	None	None
.194	9	None	None	None	None	None	None	None	None	None	None
.283	11	None	None	None	None	None	None	None	None	None	None
.244	16	None	None	None	None	None	None	None	None	None	None
.252	16	None	None	None	None	None	None	None	None	None	None
.237	16	None	None	None	None	None	None	None	None	None	None
.185	14	None	None	None	None	None	None	None	None	None	None
.227	14	None	None	None	None	None	None	None	None	None	None
.260	14	None	None	None	None	None	None	None	None	None	None
.304	14	None	None	None	None	None	None	None	None	None	None
.269	3	None	None	None	None	None	None	None	None	None	None
.527	3	None	None	None	None	None	None	None	None	None	None
.187	3	None	None	None	None	None	None	None	None	None	None
.264	3	None	None	None	None	None	None	None	None	None	None
.641	3	None	None	None	None	None	None	None	None	None	None
....	148	None	None	None	None	None	None	None	None	None	None
.014	14	None	None	None	None	None	None	None	None	None	None
.084	3	None	None	None	None	4 (1)	None	None	None	None	1
.141	3	None	None	None	None	None	None	None	None	None	None
.024	7	None	None	None	None	None	None	None	None	None	None
.020	12	None	1 (1)	None	None	None	3, 4, 5, 9 (4)	2 (1)	6, 11 (2)	None	8
.022	14	None	5 (1)	None	7 (1)	8 (1)	4 (1)	14 (1)	3 (1)	None	6
.027	14	None	None	None	None	None	None	None	None	4 (1)	1
.020	3	None	None	None	None	None	None	None	None	None	None
.013	3	None	None	None	None	None	None	None	None	None	None
.140	3	None	None	None	None	None	None	None	None	None	None
.019	3	None	None	None	None	None	None	None	None	None	None
....	79	None	2	None	1	2	5	2	3	1	16

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Second Meeting.

The second meeting was held at Philadelphia, Pa., on March 16, 1927, with Messrs. Beck, Cooper, Gibboney and Taylerson present; Messrs. Fleming, McAdam, McDonnell, Smith and Wheaton being absent. At this meeting it was decided to inspect the sheets at Annapolis, Md., on March 21, 1927, and at Fort Sheridan, Ill., on March 28, 1927.

The sheets at Annapolis were inspected by Messrs. Brooks, representing Beck, Cooper, McAdam and Taylerson; Messrs. Fleming, Gibboney, McDonnell, Smith and Wheaton being absent. The following additional failure was recorded:

Sheet X-4 (No. 22 Gage Low-Copper Pure Iron, Series B) manufactured by the Inland Steel Co. This sheet failed due to two small holes near the bottom of the sheet.

The sheets at Fort Sheridan, Ill., were inspected by Messrs. Fleming, McDonnell and Taylerson; Messrs. Beck, Cooper, Gibboney, Smith and Wheaton being absent. The following additional failures were recorded:

Sheet C-8 (No. 22 Gage Copper-Bearing Pure Iron, Series A) failed due to small holes and longitudinal cracks near the bottom of the sheet.

Sheets U-16, 19 and 21 (No. 22 Gage Copper-Bearing Pure Iron, Series B) manufactured by the Alleghany Steel Co. These sheets failed due to one or more holes near the bottom of the sheets.

Sheet X-20 (No. 22 Gage Low-Copper Pure Iron, Series B) manufactured by the Inland Steel Co. This sheet failed due to a hole near the bottom of the sheet.

No photographic record was made of the failed sheets at Annapolis and Fort Sheridan, and as very little change was noted in the general characteristics of the sheets since the last inspection no detail record covering the condition of the sheets was made.

Table I, Plate I, is presented as a continuation of the same general plan of grouping all sheets at the Fort Sheridan location as regarding the presence of copper and recording the failures at all inspection periods. It will be noted that after ten years' exposure practically all of the No. 22 gage sheets in the low-copper materials, 61 out of a total of 83 sheets, have failed, whereas only 6 copper-bearing No. 22 gage sheets out of a total of 136 have failed.

Table II, Plate II, is presented as a continuation of the same general plan of grouping all sheets at the Annapolis location as regarding the presence of copper and recording the failures at all inspection periods. It will be noted that after ten years' exposure 16 of the

No. 22 gage sheets in four groups of low-copper, open-hearth steel and pure iron have failed whereas none of the copper-bearing sheets have failed.

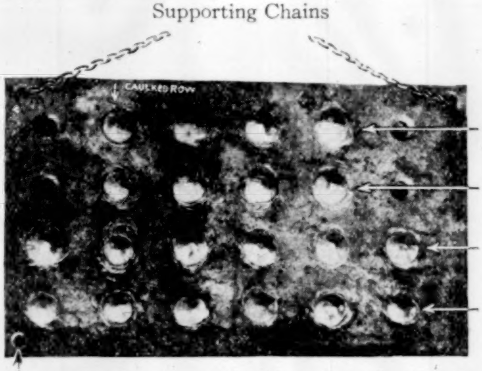
This report has been considered by the sub-committee and unanimously approved.

Respectfully submitted on behalf of the sub-committee,

J. H. GIBBONEY,
Chairman.

The remaining racks of the original tests, which now consist of the No. 16 gage sheets, at the U. S. Bureau of Standards, Washington, D. C., and at Annapolis, Md., have been periodically inspected. Of the No. 16 gage sheets at the U. S. Bureau of Standards, 142 sheets out of 150 have failed; at Annapolis, 111 sheets out of 150 have failed.

Table I (Plate III) gives the record of the No. 16 gage sheets at the Bureau of Standards, Washington, D. C. Table II (Plate IV) gives the record of the No. 16 gage sheets at the Naval Engineering Experiment Station at Annapolis, Md.



	C %	Mn %	P %	S %	Si %	Cu %
Low-Copper Steel Rivets	.08	.32	.010	.026	.01	.07
High-Copper Steel Rivets	.11	.48	.008	.029	.01	.27
Low-Copper Puddle Iron Rivets	.08	.02	.115	.010	.10	.02
Ship-Quality Steel Rivets	.20	.45	.022	.039	.01	.03

	C %	Mn %	P %	S %	Si %	Cu %
One hole indicates low-copper plates....................	0.21	0.42	0.015	0.036	0.02	0.04
Two holes indicate high-copper plates..............	0.15	0.34	0.023	0.034	0.01	0.23
Three holes indicate high-silicon plates...............	0.34	0.58	0.015	0.024	0.19	0.03

FIG. 1.—Showing Arrangement of Rivets of Various Composition in the Riveted Tests.

The additional salt water tests of samples cut from the same sheets as the original tests, have been prepared and were exposed to running sea water, at the U. S. Navy Yard at Portsmouth, N. H., on March 7, 1927, and at the U. S. Naval Station at Key West, Fla., on March 1, 1927.

The sub-committee has placed in each of the test boxes at Portsmouth and Key West, one piece of 2-in. tube, 12 in. long, of low-copper steel, and one piece of 2-in. tube, 12 in. long, of 1-per-cent copper steel.

The riveted tests (see Fig. 1) undertaken at the request of the Lloyds' Register of Shipping,[1] have been installed as follows:

At the U. S. Navy Yard, Portsmouth, N. H., exposed on July 16, 1926, under a dock, 9 ft. below low tide, rise and fall of tide, 8 ft., depth of water, 22 ft. below low tide, no wave action, no sewers or drains near test pieces.

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 26, Part I, p. 141 (1926).

At the U. S. Naval Station, Key West, Fla., exposed September 27, 1926, under a dock, 2½ ft. below low tide, rise and fall of tide, 22 in., depth of water, 8 ft., very slight wave action, no sewers or drains near test pieces.

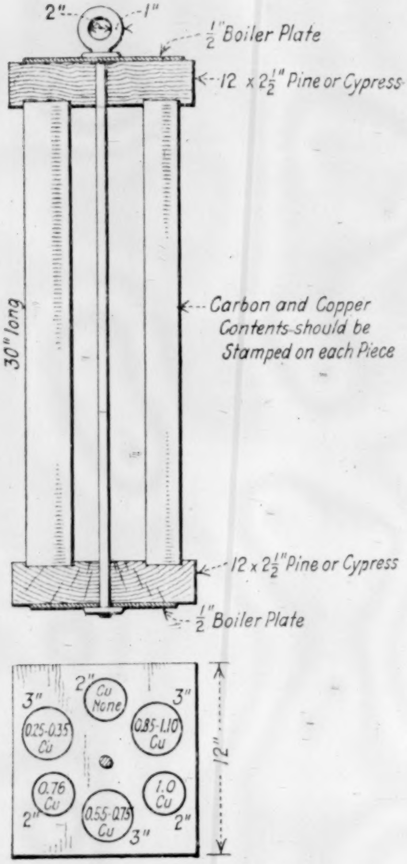
2"
1"
½" Boiler Plate
12 x 2½" Pine or Cypress
30" long
Carbon and Copper Contents should be Stamped on each Piece
12 x 2½" Pine or Cypress
½" Boiler Plate
2"
Cu None
3"
3"
0.25-0.35 Cu
0.85-1.10 Cu
0.76 Cu
1.0 Cu
0.55-0.75 Cu
2"
2"
3"
12"

FIG. 2.—Crate for Immersion Specimens of Pipe.

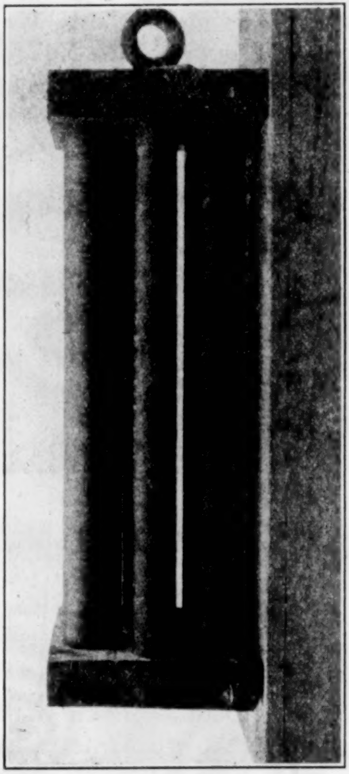

FIG. 3.—Photograph of Pipe Specimens in Immersion Tests.

At Port Arthur, Tex., in Taylor's Bayou, exposed July 26, 1926, under a dock, 9 in. below mean low Gulf level, subject to usual Gulf of Mexico tide variation, tests located 9 miles from the Gulf, with a dredged channel 30 ft. deep, and 175 ft. in bottom width.

TABLE I.—REPORT ON SUBMERGED TESTS. SHEETS EXPOSED AUGUST 10, 1920, IN RUN

No. 16 G

Group	Designation	Series	Description	Average Analysis, per cent						Number of Sheets in Test					
				Carbon	Manganese	Phosphorus	Sulfur	Silicon	Copper		Jan. 24, 1924, 1261 Days	Aug. 14, 1924, 1464 Days	Sept. 20, 1924, 1501 Days	Nov. 20, 1924, 1562 Days	Dec. 17, 1924, 1589 Days
AA	Bessemer Steel	A	Non-Copper-Bearing	0.053	0.428	0.088	0.042		0.009	6		37			
ZZ	Bessemer Steel, Youngstown Sheet and Tube Co	B	" " "	0.076	0.385	0.096	0.037		0.012	6					
II	Copper-Bearing Bessemer Steel	A	Copper-Bearing	0.055	0.381	0.099	0.066		0.236	6		55			
ZZ1	Copper-Bearing Bessemer Steel, Youngstown Sheet and Tube Co	B	" "	0.080	0.400	0.091	0.035	0.056	0.154	6					
ZZ2	Copper-Bearing Bessemer Steel, Youngstown Sheet and Tube Co	B	" "	0.088	0.306	0.089	0.046		0.271	6		213	213		
ZZ3	Copper-Bearing Bessemer Steel, Youngstown Sheet and Tube Co	B	" "	0.066	0.363	0.085	0.033		0.548	6					
OO	Basic Open-Hearth Steel	A	Non-Copper-Bearing	0.116	0.378	0.010	0.026	0.005	0.030	6	35				
MM	Basic Open-Hearth Steel, Alan Wood Iron and Steel Co	B	" " "	0.101	0.426	0.009	0.032		0.048	6					
ZZ4	Basic Open-Hearth Steel, Youngstown Sheet and Tube Co	B	" " "	0.029	0.395	0.044	0.026		0.029	6		422		427	426
BB	Basic Open-Hearth Steel	A	" " "	0.043	0.316	0.033	0.062	0.097	0.126	6					
HH	Copper-Bearing Basic Open-Hearth Steel	A	Copper-Bearing	0.085	0.391	0.013	0.025		0.230	6					39
TT	Copper-Bearing Basic Open-Hearth Steel, Newport Rolling Mill Co	B	" "	0.078	0.301	0.008	0.021		0.215	6					
ZZ5	Copper-Bearing Basic Open-Hearth Steel, Youngstown Sheet and Tube Co	B	" "	0.065	0.367	0.053	0.064		0.223	6					
ZZ6	Copper-Bearing Basic Open-Hearth Steel, Youngstown Sheet and Tube Co	B	" "	0.090	0.330	0.034	0.055		0.574	6					
ZZ7	Copper-Bearing Basic Open-Hearth Steel, Youngstown Sheet and Tube Co	B	" "	0.063	0.391	0.052	0.045		0.355	6					
CC	Low-Copper Pure Iron	A	Non-Copper-Bearing	0.021	0.033	0.004	0.031		0.060	6					
DD	Low-Copper Pure Iron	A	" " "	0.021	0.029	0.004	0.025		0.025	6					
SS	Pure Iron, American Rolling Mill Co	B	" " "	0.014	0.018	0.006	0.024		0.027	6					
XX	Pure Iron, Inland Steel Co	B	" " "	0.026	0.054	0.008	0.026		0.029	6					11
CCC	Copper-Bearing Pure Iron	A	Copper-Bearing	0.016	0.026	0.005	0.026	0.005	0.220	6					
UU	Copper-Bearing Pure Iron, Allegheny Steel Co	B	" "	0.016	0.065	0.009	0.030		0.244	6					
VV	Copper-Bearing Pure Iron, Whitaker-Glessner Co	B		0.017	0.039	0.007	0.021		0.290	6					
KK	Copper-Bearing Acid Open-Hearth Steel	A	Copper-Bearing	0.118	0.408	0.081	0.043		0.229	6					
YY	Low-Copper Puddled Iron, Youngstown Sheet and Tube Co	B	Non-Copper-Bearing	0.030	0.060	0.124	0.018	0.216	0.024	6				7	
EE	Copper-Bearing Puddled Iron	A	Copper-Bearing	0.033	0.045	0.117	0.017	0.132	0.325	6					
										150	1	4	1	2	3
	Total Failures to Date	...	...	...	...	...	...	...	...	...	1	5	6	8	11

PLATE III.
PROC. AM. SOC. TESTING MATS.
VOL. 27, PART I.
REPORT OF COMMITTEE A-5:
TOTAL IMMERSION TESTS.

RUNNING WASHINGTON CITY WATER AT THE U. S. BUREAU OF STANDARDS, WASHINGTON, D. C.
16 GAGE SHEETS

Failures on Date of Inspections																							
Dec. 17, 1924, 1589 Days	Jan. 14, 1925, 1624 Days	Feb. 28, 1925, 1662 Days	Mar. 27, 1925, 1689 Days	Apr. 27, 1925, 1720 Days	June 4, 1925, 1758 Days	July 7, 1925, 1791 Days	Aug. 7, 1925, 1822 Days	Sept. 8, 1925, 1854 Days	Oct. 20, 1925, 1896 Days	Nov. 20, 1925 1927 Days	Jan. 11, 1926, 1979 Days	Feb. 13, 1926, 2012 Days	Mar 17, 1926, 2044 Days	Apr. 19, 1926, 2077 Days	May 17, 1926 2105 Days	June 17, 1926 2136 Days	July 16, 1926, 2165 Days	Aug. 18, 1926, 2198 Days	Sept. 20, 1926, 2231 Days	Oct. 30, 1926, 2271 Days	Nov. 30, 1926, 2302 Days	Jan. 6, 1927, 2339 Days	Feb. 5, 1927, 2369 Days
			40 14, 14		52					43 7				49			8	8		8		46	
	106	106 314, 314					45, 47 208		208 310	106	40, 50	106, 106 209 310	43 311	209	107 311								
426	39	36	34	42	31			422		37 422	31, 33 40	33 426		51	53	45	47, 48						
39		510 615	715		36 507	46, 48 27	40 30, 33	42	44 714			714	615	37 510 713, 714	714	39 507, 509		612, 615			614	509	614
11		25	36	16	57		12	33	24 42	50 34			27 38			42, 52 14, 13	40				30		45 37
							33, 34, 28 37		26, 29 55	29, 30	35						32 40		43		54	32	49
		57			52			45, 47			40		50										
		1		7	1			1		7													
				23			33				30	27			25								
3	2	9	6	4	7	3	12	6	9	10	8	8	6	7	5	8	6	3	1	1	3	3	4
11	13	22	28	32	39	42	54	60	69	79	87	95	101	108	113	121	127	130	131	132	135	138	142

TABLE II.—REPORT ON SUBMERGED TESTS. SHEETS EXPOSED JUNE 2, 1920, IN RUNNING SE

NO. 16 GAGE

Group	Designation	Series	Description	Average Analysis, per cent						Number of Sheets in Test	
				Carbon	Manganese	Phosphorus	Sulfur	Silicon	Copper		
AA	Bessemer Steel	A	Non-Copper-Bearing	0.036	0.428	0.084	0.042		0.011	6	
ZZ	Bessemer Steel, Youngstown Sheet and Tube Co	B	" " "	0.080	0.427	0.081	0.031	0.008	0.014	6	
II	Copper-Bearing Bessemer Steel	A	Copper-Bearing	0.062	0.353	0.093	0.065	0.006	0.255	6	
ZZ1	Copper-Bearing Bessemer Steel, Youngstown Sheet and Tube Co	B	" "	0.112	0.412	0.109	0.045		0.167	6	1
ZZ2	Copper-Bearing Bessemer Steel, Youngstown Sheet and Tube Co	B	" "	0.076	0.340	0.088	0.034		0.291	6	
ZZ3	Copper-Bearing Bessemer Steel, Youngstown Sheet and Tube Co	B	" "	0.072	0.305	0.089	0.045		0.532	6	
OO	Basic Open-Hearth Steel	A	Non-Copper-Bearing	0.109	0.358	0.011	0.029		0.025	6	
MM	Basic Open-Hearth Steel, Alan Wood Iron and Steel Co	B	" " "	0.110	0.420	0.008	0.027	0.010	0.063	6	
ZZ4	Basic Open-Hearth Steel, Youngstown Sheet and Tube Co	B	" " "	0.060	0.390	0.040	0.024		0.033	6	417
BB	Basic Open-Hearth Steel	A	" " "	0.046	0.296	0.025	0.058		0.138	6	
HH	Copper-Bearing Basic Open-Hearth Steel	A	Copper-Bearing	0.083	0.369	0.011	0.026	0.002	0.252	6	
TT	Copper-Bearing Basic Open-Hearth Steel, Newport Rolling Mill Co	B	" "	0.087	0.338	0.008	0.019		0.221	6	
ZZ5	Copper-Bearing Basic Open-Hearth Steel, Youngstown Sheet and Tube Co.	B	" "	0.078	0.390	0.071	0.075		0.256	6	
ZZ6	Copper-Bearing Basic Open-Hearth Steel, Youngstown Sheet and Tube Co.	B	" "	0.079	0.359	0.055	0.080		0.651	6	
ZZ7	Copper-Bearing Basic Open-Hearth Steel, Youngstown Sheet and Tube Co.	B	" "	0.060	0.420	0.050	0.048		0.363	6	
CC	Low-Copper Pure Iron	A	Non-Copper-Bearing	0.022	0.031	0.005	0.031	0.003	0.086	6	
DD	Low-Copper Pure Iron	A	" " "	0.020	0.027	0.004	0.028	0.002	0.027	6	
SS	Pure Iron, American Rolling Mill Co	B	" " "	0.022	0.032	0.005	0.018	0.007	0.027	6	
XX	Pure Iron, Inland Steel Co	B	" " "	0.028	0.079	0.009	0.029		0.034	6	3
CCC	Copper-Bearing Pure Iron	A	Copper-Bearing	0.022	0.027	0.005	0.028	0.006	0.251	6	
UU	Copper-Bearing Pure Iron, Allegheny Steel Co	B	" "	0.028	0.071	0.006	0.031	0.006	0.247	6	
VV	Copper-Bearing Pure Iron, Whitaker-Glessner Co	B	" "	0.024	0.051	0.006	0.017		0.308	6	1,
KK	Copper-Bearing Acid Open-Hearth Steel	A	Copper-Bearing	0.098	0.453	0.085	0.041		0.220	6	
YY	Low-Copper Puddled Iron, Youngstown Sheet and Tube Co	B	Non-Copper-Bearing	0.030	0.050	0.127	0.018	0.197	0.024	6	
EE	Copper-Bearing Puddled Iron	A	Copper-Bearing	0.045	0.026	0.114	0.019	0.117	0.300	6	
										150	
	Total Failures to Date	...	...	...	...	...	...	...	...	...	...

PLATE IV.
PROC. AM. SOC. TESTING MATS.
VOL. 27, PART I.
REPORT OF COMMITTEE A-5:
TOTAL IMMERSION TESTS.

G SEVERN RIVER WATER AT THE NAVAL ENGINEERING EXPERIMENT STATION, ANNAPOLIS, MD.

5 GAGE SHEETS

Number of Sheets in Test	Aug. 6, 1925, 1890 Days	Sept. 9, 1925, 1924 Days	Oct. 22, 1925, 1967 Days	Nov. 24, 1925, 2000 Days	Feb 19, 1926, 2087 Days	Mar. 25, 1926, 2121 Days	Apr. 24, 1926, 2151 Days	May 24, 1926, 2181 Days	June 24, 1926, 2212 Days	July 28, 1926, 2246 Days	Aug. 27, 1926, 2276 Days	Sept. 28, 1926, 2308 Days	Nov. 4, 1926, 2345 Days	Dec. 4, 1926, 2378 Days	Jan. 12, 1927, 2414 Days	Feb. 12, 1927, 2445 Days
6		1, 10														
6	4	1			2					2						
6		1, 10											9			
6	103, 102, 102	102								103	103					
6	202	201					202							204		
6		307									306					307
6	1, 3, 4, 6	7, 8														
6	2, 7, 15				5											
6	417, 418, 418, 418			417												
6	3, 6, 9, 15						1									
6	2, 5, 12						16									
6	1, 6, 8, 9							12			3					
6	503	501				503, 503									501	
6																
6																
6	7	3			5		8			1			10			
6	11, 15, 16	12, 13					21									
6	3, 9, 17					6, 12										
6	3, 5, 7, 32, 35	2														
6	3, 4, 12, 15								8			13				
6	4, 6, 7, 8		1							3						
6	1, 19, 30, 31, 32						21									
6	9, 12, 16	6					3						7			
6	8, 8, 8, 8	9				9										
6							9									
150	60	17	1	1	3	5	8	1	1	4	3	1	3	1	1	1
....	....	77	78	79	82	87	95	96	97	101	104	105	108	109	110	111

At Portsmouth and Key West it is presumed that the water is of a comparatively uniform character, excepting the temperature, but at Port Arthur, the conditions are very different. Under date of December 9, 1926, it was reported that an analysis of the water surrounding the test specimens was made, and showed 22 per cent of sea water, and 78 per cent of fresh water, with a slight trace of alkali, which all waters in this vicinity carry. As additional information, it was stated that during periods of heavy rain, the water where these specimens are immersed, is practically fresh, and that during periods of drought it is practically sea water. A fair yearly average of the water would be 50 per cent of sea water, and 50 per cent of fresh water.

The U. S. Bureau of Standards has analyzed the plates and rivets used in these tests, the results being as follows:

	Carbon, per cent	Manganese, per cent	Phosphorus, per cent	Sulfur, per cent	Silicon, per cent	Copper, per cent
Low-Copper Plates (one hole)...	0.21	0.42	0.015	0.036	0.02	0.04
High-Copper Plates (two holes).	0.15	0.38	0.023	0.034	0.01	0.23
High-Silicon Plates (three holes).	0.34	0.58	0.015	0.024	0.19	0.03
Low-Copper Steel Rivets.......	0.08	0.32	0.010	0.026	0.01	0.07
High-Copper Steel Rivets.......	0.11	0.48	0.008	0.029	0.01	0.27
Low-Copper Puddled Iron Rivets	0.08	0.02	0.115	0.010	0.10	0.02
Ship Quality Steel Rivets.......	0.20	0.45	0.022	0.039	0.01	0.03

The sub-committee has also exposed at Portsmouth, Key West, and Port Arthur, with the riveted tests, and on the same dates, racks containing three 2-in. tubes 30 in. long, and three 3-in. tubes 30 in. long. (See Figs. 2 and 3.) Each rack contains tubes as follows:

	Carbon, per cent	Copper, per cent
One 2-in. tube....................	0.10 – 0.20	None
One 2-in. tube....................	0.10 – 0.20	0.76
One 2-in. tube....................	0.10 – 0.20	1.00
One 3-in. tube....................	0.30 – 0.40	0.25 – 0.35
One 3-in. tube....................	0.30 – 0.40	0.55 – 0.75
One 3-in. tube....................	0.30 – 0.40	0.85 – 1.10

The riveted test pieces and the tubes are to be inspected every four months, as follows: January 1, May 1, and September 1. At every inspection the test pieces and the tubes are to be brushed and, if necessary, scraped to remove all marine growth and deposits.

Respectfully submitted on behalf of the sub-committee,

William A. Cooper,
Chairman.

REPORT OF SUB-COMMITTEE VI ON SPECIFICATIONS FOR METALLIC-COATED PRODUCTS

In 1924, the sub-committee prepared tentative specifications for galvanized sheets, entitled Tentative Specifications for Hot-Dipped Galvanized Sheets (A 93 – 24 T).[1] These have been incomplete in that they do not cover all commercial classes although appearing to be approximately correct for the three classes described. These specifications have now been very thoroughly studied by the sub-committee, resulting in a complete revision which is appended hereto.[2] The specifications as revised include a fourth class corresponding to ordinary commercial sheets and a fifth class which covers tight-coated sheets for severe forming. The sub-committee recommends that the revised specifications be adopted as standard.

The sub-committee has continued its study of specifications for wire and wire products and now offers extensive revisions of the following present tentative specifications:

Tentative Specifications for the Coating on Zinc-Coated (Galvanized) Wire (A 110 – 26 T);[3]
Tentative Specifications for Zinc-Coated (Galvanized) Iron or Steel Telephone and Telegraph Line Wire (A 111 – 26 T);[3]
Tentative Specifications for Zinc-Coated (Galvanized) Iron or Steel Tie Wires (A 112 – 26 T).[3]

The specifications are appended hereto[4] in their proposed revised form. New specifications have been prepared as appended hereto[5] as follows:

For Zinc-Coated (Galvanized) Wire Fencing;
For Zinc-Coated Chain-Link Fence Fabric Galvanized Before Weaving;
For Zinc-Coated Chain-Link Fence Fabric Galvanized After Weaving.

The proposed revised tentative specifications and the proposed new specifications are recommended for acceptance for publication as tentative.

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 24, Part I, p. 775 (1924); also 1926 Book of A.S.T.M. Tentative Standards, p. 103.

[2] See 1927 Book of A.S.T.M. Standards, Part I, p. 270.—Ed.

[3] *Proceedings*, Am. Soc. Testing Mats., Vol. 26, Part I, pp. 664–674 (1926); also 1926 Book of A.S.T.M. Tentative Standards, pp. 107–115.

[4] See pp. 696, 679 and 684.—Ed.

[5] See pp. 687–695.—Ed.

The sub-committee has continued its study of methods of test and specifications for the zinc coating on galvanized iron and steel pipe. Neither bend nor tension tests have been found to give sufficiently uniform and reliable results to serve as specification requirements for toughness and adherence of the zinc coating. Considering the small percentage of such pipe which is bent in actual application. it is recommended that physical tests of the coating are not necessary. The sub-committee has revised its other recommended requirements for zinc coating of pipes, to read as follows:

> *Weight of Coating.*—The weight of the zinc coating on either the inside or outside of galvanized pipe shall not be less than 2 oz. per sq. ft. of single surface.
>
> *Workmanship and Finish.*—The coating on galvanized pipe shall be of first class commercial quality and free from injurious defects.

The sub-committee recommends that these clauses be presented to Committees A-1 on Steel and A-2 on Wrought Iron as the recommendation of Committee A-5, for requirements for the coating on galvanized pipe, to be used in their specifications for steel and iron pipe.

The sub-committee is continuing the collection of data on sherardized coatings, preliminary to attempting the formulation of specifications.

Investigations are being continued on wire products, both in the further study of the tentative specifications already written as well as requirements for still other wire products.

This report has been considered by the sub-committee and has been approved by letter ballot.

Respectfully submitted on behalf of the sub-committee,

H. E. SMITH,
Chairman.

REPORT OF SUB-COMMITTEE VII ON METHODS OF TESTING

Sub-Committee VII held its organization meeting in Philadelphia on October 28, 1926. The entire group of men comprising this committee had been organized on April 14, 1926, as Technical Committee VII (Methods of Testing) of the Sectional Committee on Zinc Coatings, for which the Society is the sponsor, functioning under the rules of the American Engineering Standards Committee. The organization of this group as a sub-committee of Committee A-5 was arranged to afford better correlation of work on methods of testing with field exposure tests and to provide a working committee in Committee A-5 which would also interest itself in methods of testing metal coatings other than zinc. However, up to the present, Sub-Committee VII has considered only zinc coatings.

The organization meeting of Sub-Committee VII of Committee A-5 and considerable time before and after was devoted to attempting to define the work of the committee. As a result of discussions and questionnaires, it soon became evident that the methods of testing of the nature of the following were needed:

> Quickly performable tests to judge whether or not the physical properties of zinc coatings will enable them to withstand the commercial fabricating operations required of them.
>
> Quickly performable tests to determine weight of coating and impurities.
>
> Quickly performable tests to determine uniformity of zinc coatings and the ability of zinc-coated products to resist corrosion on exposure to weather.

As regards the method of physical and corrosion testing, it became evident at an early date that there were no quickly performable tests that were generally favored by the majority of the sub-committee and therefore that could be approved as methods of testing to be written into specifications. Accordingly, much of the work of the subcommittee must be largely investigational for some time.

The division of the sub-committee into sub-sub-committees, and the plans of these sections are as follows:

Sub-Committee VII-A, Physical Tests of Coatings, W. H. Moore, chairman.—This section has laid its plans to collect a number of samples of the most generally used gages of galvanized sheet and wire and to put these samples through the following experimental program. All the samples will be put through such quickly performable or inspection tests as flexure and bending tests and cupping tests. Also, companion sheet samples will be submitted to manufacturing operations such as the following: beading, crimping, wire edging, corrugating, seaming, deep drawing, and curving of corrugated sheets. By correlating the deportment of the sheet samples in the quickly performable and in the manufacturing tests, it is hoped that the committee may be able to select reliable inspection test methods and write a manual of directions for their operation.

In the case of the wire samples, the following quickly performable inspection tests will be used: flexure or bending tests, mandrel tests, repeated bending and torsion tests, and tension tests. Likewise, the wire samples will be submitted to fabricating operations such as splicing and weaving. By correlating the deportment of wire samples in both inspection and manufacturing forms of test, it is hoped to select a reliable inspection test method and write instructions for its operation.

Sub-Committee VII-B, Quantitative Analyses of Coatings, Howard E. Brooks, chairman.—This section is working to determine which of the various weights of coating test are most generally favored. Stripping tests such as the following are available from which to make a selection: hydrochloric acid, hydrochloric acid - antimony chloride, sulfuric acid, sulfuric acid - potassium permanganate, thermal testing method, and hydrogen evolution method. This committee also is working to define methods of analysis that should be standardized for determining the impurities such as iron, tin, lead, aluminum, etc., that may be contained either in zinc coatings or in the slab zinc used for galvanizing.

Sub-Committee VII-C, Other Characteristics of Coating, F. A. Hull, chairman.—This section is concerned with uniformity and corrosion tests. The section has its plans laid to collect a number of samples of zinc-coated wire, sheet and hardware which will be submitted to a variety of quickly performable tests such as the following: Preece test, hydrogen peroxide, acetic acid test, salt spray test, intermittent immersion in ammonium chloride, etc. The committee is working on the hypothesis that in order to determine which of these tests are reliable indications of ability to resist weathering corrosion, the only certain corroborative test is actual weather exposure of companion specimens. This will become possible later by correlation with the field test results of Sub-Committee VIII. However, as this will require several years, Sub-Committee VII-*C* is in the meantime proposing to use the best available accelerated weathering test as a criterion by means of which to judge the value of the quickly performable tests. This particular accelerated weathering test is a simulated industrial atmospheric test developed by The New Jersey Zinc Co.[1] It involves exposure to cycles of air charged with sulfur dioxide and carbon dioxide, artificial rain, and drying periods. Considerable corroborative evidence has been obtained by The New Jersey Zinc Co. that this test is usually able to rate different zinc-coated samples in the approximate order of their weather resisting qualities, and therefore is a reasonable reference test. However, it is recognized by Sub-Committee VII that the test is not demonstrated to be infallible. It is regarded simply as the most expedient procedure at present to use this reference testing method.

A sub-sub-committee under the chairmanship of W. H. Finkeldey, reporting to Sub-Committee VII-*C*, has been appointed to further study the factors which influence the operation of The New Jersey Zinc Co. test, even though the test is to be used in its present state of development for the preliminary work of Sub-Committee VII-*C*.

Sub-Committee VII-D, Provision of Test Specimens, L. E. Hopkins, chairman.—This section is made up of the chairmen of the other sub-committees plus two or three other people chosen at large from the general committee. It is expected to function partially as an advisory and correlating committee, since its personnel contains other sub-committee chairmen. It will also function as its name implies, as a committee to collect samples for test which are needed by all the sub-committees. For performing this latter function, the chairman of Sub-Committee VII-*D* will act as the business agent.

Respectfully submitted on behalf of the sub-committee,

C. D. HOCKER,
Chairman.

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[1] See paper by H. S. Rawdon, A. I. Krynitsky and W. H. Finkeldey, "Types of Apparatus Used in Testing the Corrodibility of Metals," *Proceedings*, Am. Soc. Testing Mats., Vol. 24, Part II, p. 717 (1924).

REPORT OF SUB-COMMITTEE VIII ON FIELD TESTS OF METALLIC COATINGS

On October 22, 1924, the following committee was appointed to develop locations for and design of test rack and to place the sheet specimens thereon:

C. S. Trewin, *Chairman*
J. A. Aupperle
W. R. Fleming
J. H. Gibboney
B. F. Hammel
F. A. Hull
T. P. Sager
H. E. Smith
E. S. Taylerson

Their plans were approved by Sub-Committee VIII and have been carried out practically in full.

LOCATIONS OF TEST RACKS

It was decided that, at present, there should be erected a sufficient number of test racks to give a fairly representative cross-section of the atmospheric conditions met by metallic-coated products. These conditions may be generalized as a severe industrial atmosphere, a moderate industrial atmosphere, a pure rural atmosphere, a foggy temperate sea-coast atmosphere, and a humid sea-coast atmosphere. The committee secured locations where the atmospheric conditions approximate those desired, with the understanding that the specimens will remain, undisturbed, for at least twenty-five years.

The rack exposed to the severe industrial atmosphere is located at Brunot Island, in the Ohio River, about two miles west of Pittsburgh, Pa., on the property, and through the courtesy, of the Duquesne Light Co.

The moderate industrial exposure is located at Altoona, Pa., on the roof of the storehouse of the Juniata shops, and through the courtesy of the Pennsylvania Railroad.

The rural exposure is located on the grounds of the Agricultural Department of the Pennsylvania State College, State College, Pa., about one and one-half miles from the college buildings. The racks were erected through the courtesy of the officials of that college.

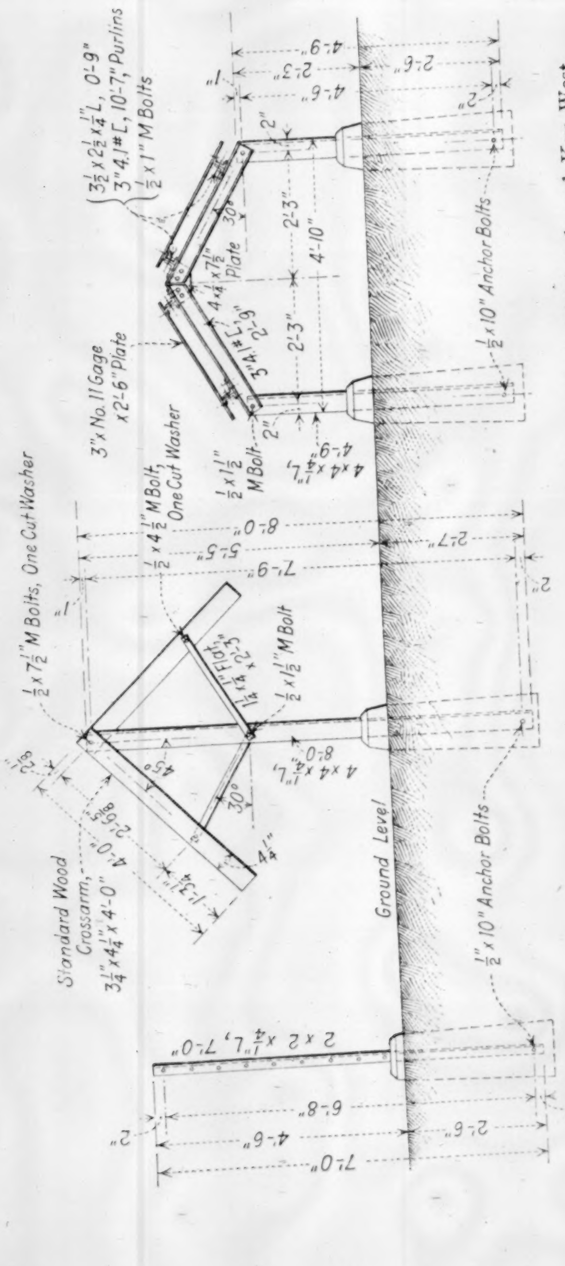

$3\frac{1}{2}$ x $2\frac{1}{2}$ x $\frac{1}{4}$" L, 0'-9"
3" 4.1# L, 10'-7", Purlins
$\frac{1}{2}$ x 1" M Bolts
3" x No. 11 Gage x 2'-6" Plate
$4\frac{1}{4}$ x $7\frac{1}{2}$" Plate
3" 4.1# L, 2'-9"
30°
2"
2'-3"
4'-10"
4'-9"
2'-3"
4'-6"
2'-6"
1"
2"
$\frac{1}{2}$ x $1\frac{1}{2}$" M Bolt
4 x 4 x $\frac{1}{4}$" L, 4'-9"
$\frac{1}{2}$ x 10" Anchor Bolts
$\frac{1}{2}$ x $7\frac{1}{2}$" M Bolts, One Cut Washer
$\frac{1}{2}$ x $4\frac{1}{2}$" M Bolt, One Cut Washer
$1\frac{1}{4}$ x $\frac{1}{4}$" Flat, x 2'-3"
$\frac{1}{2}$ x $1\frac{1}{2}$" M Bolt
4 x 4 x $\frac{1}{4}$" L, 8'-0"
8'-0"
5'-5"
7'-9"
2'-7"
45°
30°
$4\frac{1}{4}$"
Standard Wood Crossarm, $3\frac{1}{4}$" x $4\frac{1}{4}$" x 4'-0"
4'-0"
$2'-5\frac{5}{8}$"
$1'-3\frac{1}{4}$"
$\frac{3}{8}$"
Ground Level
$\frac{1}{2}$" x 10" Anchor Bolts
2 x 2 x $\frac{1}{4}$" L, 7'-0"
6'-8"
4'-6"
7'-0"
2'-6"
2"

FIG. 1.—Cross-Section of the Sheet, Wire and Fencing Racks at Sandy Hook, Pittsburgh and Key West.

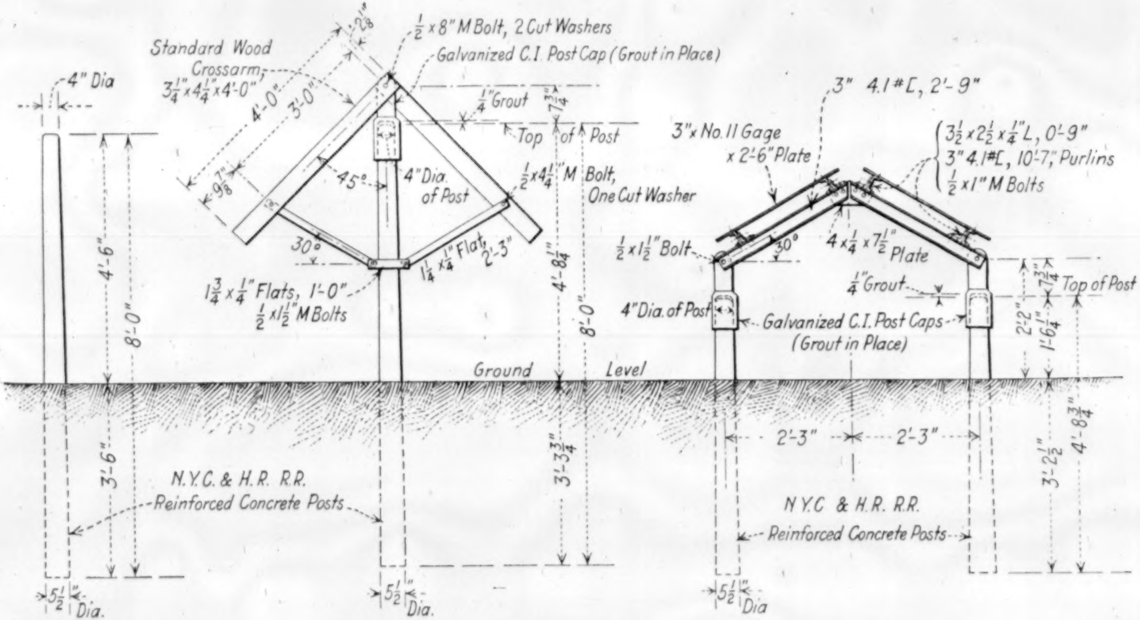

4" Dia
4'-6"
8'-0"
3'-6"
$5\frac{1}{2}$" Dia.
Standard Wood Crossarm, $3\frac{1}{4}$" x $4\frac{1}{4}$" x 4'-0"
4'-0"
3'-0"
$2\frac{7}{8}$"
$9\frac{7}{8}$"
$\frac{1}{2}$ x 8" M Bolt, 2 Cut Washers
Galvanized C.I. Post Cap (Grout in Place)
$\frac{1}{4}$" Grout
$7\frac{3}{4}$"
Top of Post
45°
4" Dia. of Post
30°
$\frac{1}{2}$ x $4\frac{1}{4}$" M Bolt, One Cut Washer
$1\frac{1}{4}$ x $\frac{1}{4}$" Flat, 2'-3"
$1\frac{3}{4}$ x $\frac{1}{4}$" Flats, 1'-0"
$\frac{1}{2}$ x $1\frac{1}{2}$" M Bolts
4'-$8\frac{1}{4}$"
8'-0"
3'-$3\frac{3}{4}$"
$5\frac{1}{2}$" Dia.
Ground Level
N.Y.C. & H.R. R.R. Reinforced Concrete Posts
3" 4.1# [, 2'-9"
3" x No. 11 Gage x 2'-6" Plate
$3\frac{1}{2}$ x $2\frac{1}{2}$ x $\frac{1}{4}$" L, 0'-9"
3" 4.1# [, 10'-7", Purlins
$\frac{1}{2}$ x 1" M Bolts
$\frac{1}{2}$ x $1\frac{1}{2}$" Bolt
30°
4 x $\frac{1}{4}$ x $7\frac{1}{2}$" Plate
$\frac{1}{4}$" Grout
Top of Post
$7\frac{3}{4}$"
4" Dia. of Post
Galvanized C.I. Post Caps (Grout in Place)
2'-2"
1'-$6\frac{1}{4}$"
4'-$8\frac{3}{4}$"
2'-3"
2'-3"
3'-$2\frac{1}{2}$"
N.Y.C. & H.R. R.R. Reinforced Concrete Posts
$5\frac{1}{2}$" Dia

FIG. 2.—Cross-Section of the Sheet, Wire and Fencing Racks at State College.

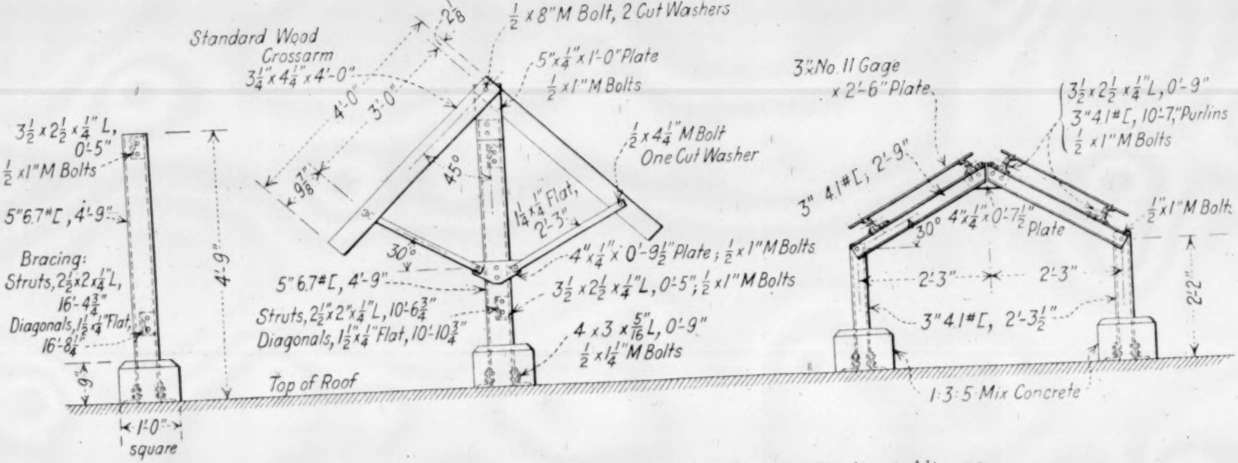
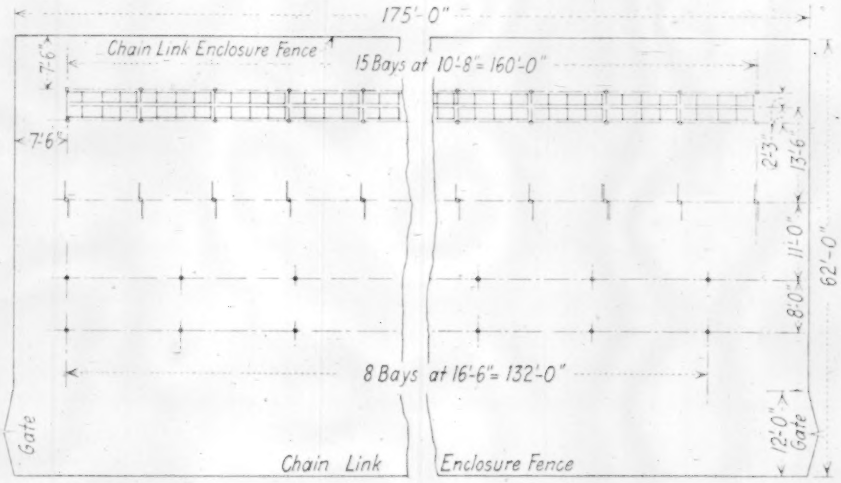
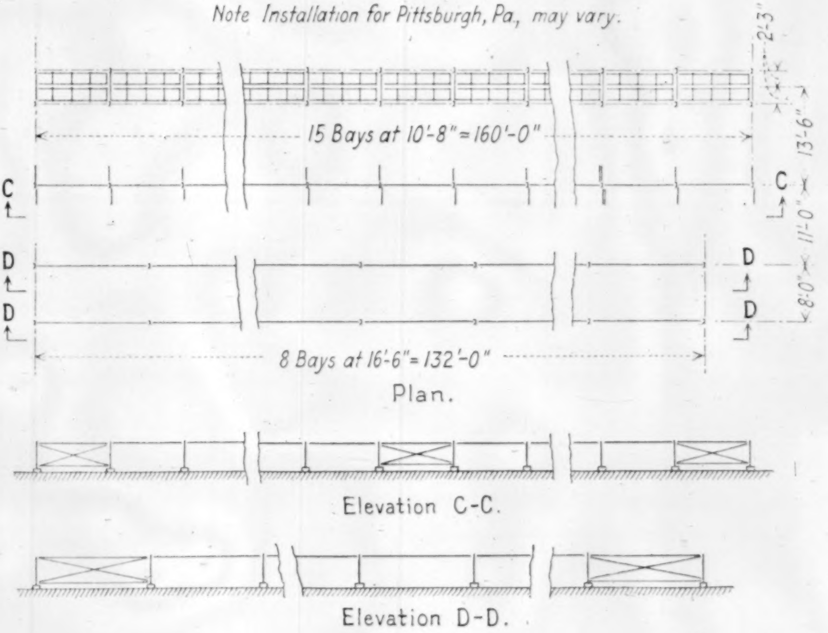

3½ x 2½ x ¼" L, 0'-5"
½ x 1" M Bolts
5" 6.7# [, 4'-9"
Bracing:
Struts, 2½ x 2 x ¼" L, 16'-4¾"
Diagonals, 1½ x ¼" Flat, 16'-8¼"
4'-9"
9"
1'-0" square
Standard Wood Crossarm 3¼" x 4¼" x 4'-0"
4'-0"
3'-0"
2⅛"
9⅞"
½ x 8" M Bolt, 2 Cut Washers
5" x ¼" x 1'-0" Plate
½ x 1" M Bolts
45°
30°
½ x 4¼" M Bolt
One Cut Washer
1¼ x ¼" Flat, 2'-3"
4" x ¼" x 0'-9½" Plate ; ½ x 1" M Bolts
5" 6.7# [, 4'-9"
3½ x 2½ x ¼" L, 0'-5"; ½ x 1" M Bolts
Struts, 2½" x 2" x ¼" L, 10'-6¾"
Diagonals, 1½" x ¼" Flat, 10'-10¾"
4 x 3 x 5/16" L, 0'-9"
½ x 1¼" M Bolts
Top of Roof
3" No. 11 Gage x 2'-6" Plate
3" 4.1# [, 2'-9"
30°
4" x ¼" x 0'-7½" Plate
3½ x 2½ x ¼" L, 0'-9"
3" 4.1# [, 10'-7" Purlins
½ x 1" M Bolts
½" x 1" M Bolt
2'-3"
2'-3"
2'-2"
3" 4.1# [, 2'-3½"
1:3:5 Mix Concrete

FIG. 3.—Cross-Section of the Sheet, Wire and Fencing Racks at Altoona.


175'-0"
Chain Link Enclosure Fence
15 Bays at 10'-8" = 160'-0"
7'-6"
7'-6"
2'-3"
13'-6"
11'-0"
62'-0"
8'-0"
8 Bays at 16'-6" = 132'-0"
Gate
12'-0"
Gate
Chain Link Enclosure Fence

SANDY HOOK, N.J.; KEY WEST, FLA.; STATE COLLEGE, PA.;
PITTSBURGH, PA

Note Installation for Pittsburgh, Pa., may vary.


2'-3"
15 Bays at 10'-8" = 160'-0"
13'-6"
C
C
11'-0"
D
D
D
D
8'-0"
8 Bays at 16'-6" = 132'-0"
Plan.
Elevation C-C.
Elevation D-D.

ALTOONA, PA.

FIG. 4.—Erection Diagram of Racks at each Test Location.

The foggy sea-coast exposure is located within the government reservation at Fort Hancock, Sandy Hook, N. J., through the courtesy of the U. S. War Department.

The tropical exposure is located within the reservation of the U. S. Naval Station at Key West, Fla., through the courtesy of the U. S. Navy Department.

DESIGN OF RACKS

At each test station it was proposed to expose specimens of all commercial metallic-coated iron and steel products. This involves sheet, wire, wire products and hardware.

It was decided to erect three racks at each test station, one for sheet, one for wire and hardware and the other for wire fencing. Figures 1 to 3 illustrate the cross-section of the sheet, wire and fencing racks. Figure 4 shows the plan view of the racks at each test location.

Sheet Rack:

The sheet rack consists of fifteen 10 ft. 8 in. bays. The purlins and truss members are galvanized channels. It was planned to make the supporting posts for the rack of concrete with galvanized cast-iron caps. This construction was followed at State College as indicated in Fig. 2. Unfortunately, these posts were so damaged in transit that it seemed undesirable to erect the other racks in this manner.

The posts for the Brunot Island, Sandy Hook and Key West racks are galvanized iron angles embedded in concrete footings.

The Altoona rack, as it was placed on a roof of a building, was erected with galvanized iron supports as originally designed.

Wire Rack:

The wire rack consists of fifteen, 10 ft. 8 in. bays, the wire samples to be placed on glass or porcelain knobs which in turn will be supported by standard wooden telephone cross arms. The uprights for this rack at the State College station are concrete posts, at the other locations they are galvanized angles embedded in concrete, for the reason as mentioned above. Two of the bays on the wire rack are to be devoted to hardware samples.

Fence Rack:

The posts at State College are concrete fence posts. There are two lines of posts of eight 16½-ft. bays. These posts, at Sandy Hook, Key West and Brunot Island, are galvanized iron angles embedded in concrete, for the reason mentioned above, while the Altoona rack consists of galvanized angles as originally designed.

The bolts, purlins and truss members for the sheet rack and the straps for the wire rack at Brunot Island, State College, Sandy Hook and Key West, and the steel for the entire Altoona rack was galvanized by the Aeromotor Co. of Chicago, Ill.

The galvanized posts for the sheet rack, the posts for the wire rack and the fence posts at the Brunot Island, Sandy Hook and Key West racks were galvanized by the Riter Conley Co. of Pittsburgh, Pa.

The erection of these racks, with the exception of the Key West rack, was carried out by a crew supplied by the Pennsylvania Railroad and The New Jersey Zinc Co. The Key West rack was erected by the Navy Department.

The State College rack was completed October 18, 1925; the Altoona rack, November 15, 1925; the Brunot Island rack, December 12, 1925; the Key West rack, February 9, 1926; and the Sandy Hook rack, March 27, 1926.

ENCLOSING FENCES

While all the racks are upon private property which is under close observation, it was thought desirable to enclose the test station with a protection fence. Accordingly, the Cyclone Fence Co. and the Page Steel and Wire Co. erected a standard 6-ft. chain-link fabric fence, surmounted by three strands of barbed wire, each location equipped with a standard gate. The area enclosed by the fence is 175 ft. long by 60 ft. wide, there being an aisle 7½ ft. wide between the ends of the racks and the enclosing fence.

These fences were erected at Brunot Island, State College, Sandy Hook and Key West at about the same time as the racks were erected, half of each fence on each location being erected by each company.

SHEET SPECIMENS

It was decided that the sheet specimens should consist of hot-dip galvanized sheets, terne-coated sheets and lead-coated sheets. At present, only the hot-dip galvanized sheets have been erected.

Galvanized Sheets:

The following five nominal weights of coatings were chosen as representing the commercial weights now found on the market: 2½, 2, 1½, 1¼ and ¾ to 1 oz. per sq. ft.

Bases.—There were five bases chosen:

Open-hearth iron, the copper content not to exceed 0.05 per cent;

Copper-bearing open-hearth iron, the copper content to be 0.20 per cent minimum;

Open-hearth steel, the copper content not to exceed 0.05 per cent;

Copper-bearing open-hearth steel, the copper content to be 0.20 per cent minimum;

Wrought iron.

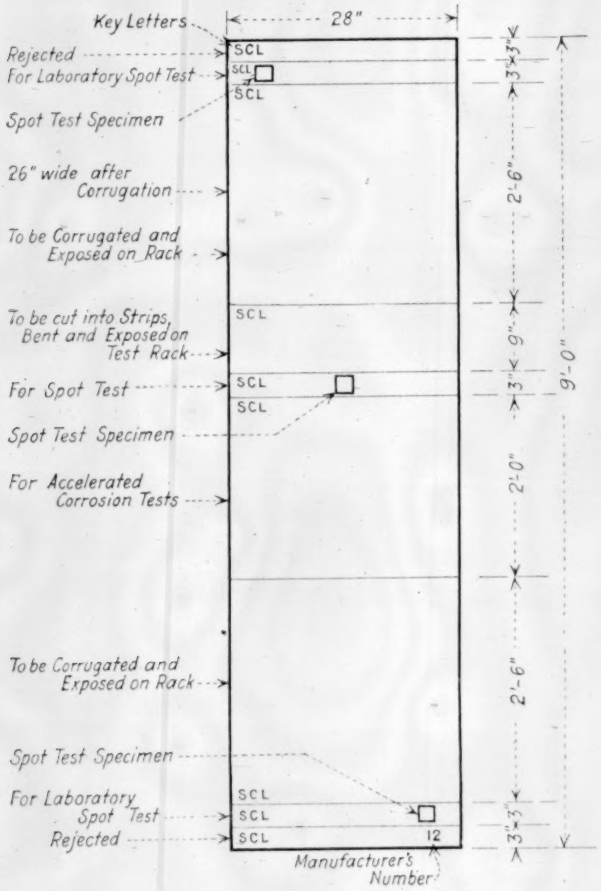

Key Letters
28"
Rejected
SCL
For Laboratory Spot Test
SCL
SCL
Spot Test Specimen
26" wide after Corrugation
To be Corrugated and Exposed on Rack
To be cut into Strips, Bent and Exposed on Test Rack
SCL
For Spot Test
SCL
SCL
Spot Test Specimen
For Accelerated Corrosion Tests
To be Corrugated and Exposed on Rack
Spot Test Specimen
For Laboratory Spot Test
SCL
SCL
Rejected
SCL
12
Manufacturer's Number
3"
3"
2'-6"
9"
3"
2'-0"
2'-6"
3"
3"
9'-0"

FIG. 5.—Sketch to Illustrate the Sampling and Marking of Sheets Before Corrugating.

Number of Sheets per Rack:

Upon each rack there are samples from two sheets of each base of the first four bases and each weight of coating, the two sheets being made by different manufacturers in order that the test samples might truly represent the commercial types of products produced, and not a single manufacturer's product. In order that there be no lack of material for future or check investigations, 16 sheets of each base and weight of coating of each product were made by each manufacturer.

Gages:

The gage of the sheets first specified for the above bases and weights of coating was approximately No. 22 Galvanized Sheet Gage. It was later decided to include No. 16-gage, 2½-oz. coated sheets with the first four bases and No. 28-gage, ¾ to 1-oz. coated sheets with the four bases as these would represent the product frequently used with these heavier and lighter coatings.

Sheet and Specimen Dimensions:

The committee specified a sheet 108 in. long by 28 in. wide, resulting in a width of 26 in. for the corrugated specimens. It was cut as illustrated in Fig. 5, the first 3 in. to be scrap, the next 3 in. for spot tests, the next 30 in. to be corrugated and erected on the racks, the next 9 in. for bend specimens, the next 3 in. for spot tests, the next 24 in. for accelerated corrosion tests, the next 30 in. to be corrugated and erected on the exposure rack, the next 3 in. for spot tests and the next 3 in. for scrap.

Manufacture and Inspection of Sheets:

A committee consisting of M. E. McDonnell, R. L. Duff, C. S. Trewin and F. A. Hull, chairman, was appointed to observe the manufacture and sampling of the sheets and to supervise the disposition and erection of the specimens.

The following producers supplied the committee with the necessary sheets:

American Rolling Mill Co.—Open-hearth iron base No. 22-gage, 2½-oz., 2-oz., 1½, and 1¼-oz. coatings; and No. 16-gage, 2½-oz. coating.

Andrews Steel Co.—Copper-bearing open-hearth iron base, No. 22-gage, 2½-oz., 2-oz., 1½-oz., 1¼-oz., and ¾ to 1-oz.; and No. 28-gage, ¾ to 1-oz. coating.

United Alloy Steel Co.—Open-hearth iron base, No. 22-gage, 2½-oz., 2-oz., 1½-oz., 1¼-oz. and ¾ to 1-oz.; No. 16-gage, 2½-oz.; and No. 28-gage, ¾ to 1-oz. coating.

Copper-bearing open-hearth iron base, No. 22-gage, 2½-oz., 2-oz., 1½-oz., 1¼-oz., and ¾ to 1-oz. coating; and No. 16-gage, 2½-oz. coating.

Youngstown Sheet and Tube Co.—Open-hearth steel base, No. 22-gage, 2½-oz., 2-oz., 1½-oz., 1¼-oz., and ¾ to 1-oz. coating. No. 16-gage, 2½-oz., and No. 28-gage, ¾ to 1-oz. coating.

Copper-bearing open-hearth steel base, No. 22-gage, 2½-oz., 2-oz., 1½-oz., 1¼-oz., and ¾ to 1-oz. coating.

American Sheet and Tin Plate Co.—Open-hearth steel base, No. 22-gage, 2½-oz., 2-oz., 1½-oz., 1¼-oz., and ¾ to 1-oz. coating; No. 16-gage, 2½-oz.; and No. 28-gage, ¾ to 1-oz. coating.

Copper-bearing open-hearth steel base, 2½-oz., 2-oz., 1½-oz., 1¼-oz., and ¾ to 1-oz. coating; No. 16-gage, 2½-oz.; and No. 28-gage, ¾ to 1-oz. coating.

The A. M. Byers Pipe Co. supplied wrought-iron sheet bars, which were rolled into No. 22-gage sheets by The Apollo Steel Co. and galvanized by The American Sheet and Tin Plate Co., with the following weights of coating: 2½-oz., 2-oz., 1½-oz., 1¼-oz.

Each manufacturer also supplied black stock of the same base material and gage as that galvanized.

For the black No. 22-gage 28 by 108-in. sheets, the weight of 27.9 lb. with a variation of ± 3 per cent, minimum, 27.05 lb., maximum, 28.75 lb., was adopted for all weights of coating. For the black No. 16-gage the weight limits were set at from 50.95 to 54.05 lb.

The following variations were adopted for the allowable variations in weight test of coating:

WEIGHT OF COATING, OZ. PER SQ. FT.	PERMISSIBLE RANGE IN WEIGHT, OZ. PER SQ. FT.
2.5	2.30 – 2.70
2.0	1.85 – 2.15
1.5	1.40 – 1.60
1.25	1.15 – 1.35
0.75 to 1	0.75 to 1

The committee was present during the galvanizing at four of the mills. Subsequently, it was requested by the American Rolling Mill Co. that their sheets be replaced by those of a newly developed grade. This request was granted by the chairman of Committee A-5, but the committee did not observe the galvanizing of the second lot of material. The first lot of open-hearth iron sheets submitted by the United Alloy Steel Co. were outside the specified copper content. A second but smaller lot was submitted, the galvanizing of which was not observed by the committee. The committee did not observe the galvanizing of any of the sheets of the Youngstown Sheet and Tube Co.

The general procedure observed in galvanizing the sheets was as follows: The producer rolled sufficient sheets of each gage to come within the limits specified above for black sheets. These sheets were stamped in one corner with a steel die with consecutive numbers. The sheets were pickled, carefully dried and individually weighed, and the weights recorded. The committee accepted these black weights. The pot was adjusted for the coating desired and the sheets run through with the number on the top side and back end of the sheet. Fifty sheets of each base were coated with each of the weights desired. The weight of each individual sheet was determined after galvanizing and from the difference the weight of coating was determined. The sheets were inspected for surface defects and sixteen of the sheets of each base with the specified coating weights were chosen by the committee as representing sheets produced by the manufacturer.

The unsheared flat sheets were carefully packed and forwarded to the American Sheet and Tin Plate Co. at Vandergrift, Pa., where the committee assembled, with representatives of the producers, to mark and shear the specimens.

Marking and Cutting Up:

A system of marking, consisting of three letters, was developed to designate the sheets, the first letter representing the producer and the base material, the second letter representing the gage and weight of coating, and the third letter, the sheet number. The key to the letters is as follows:

FIRST LETTER

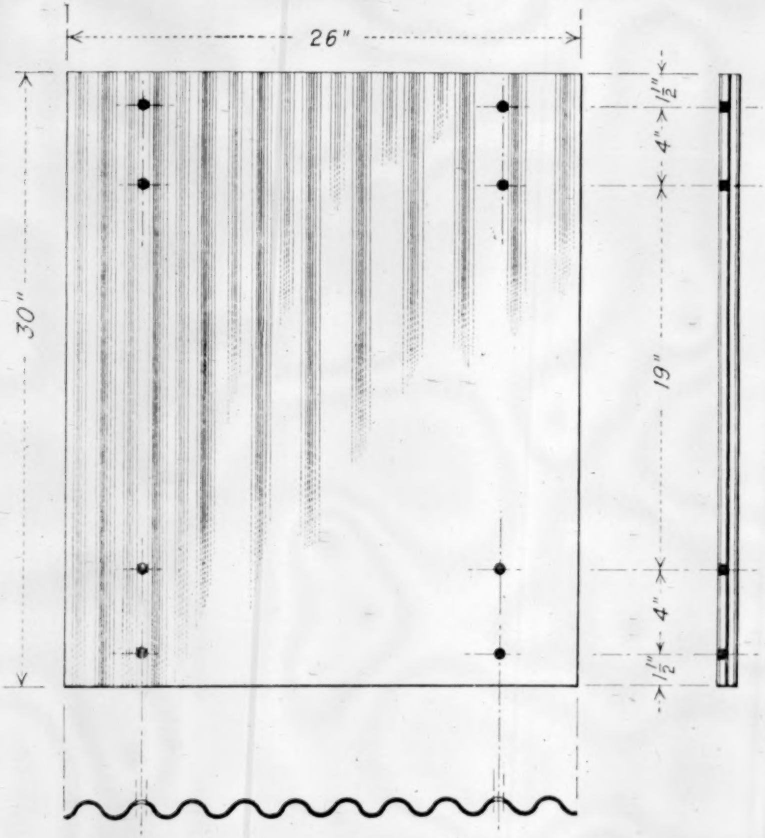
R	American Rolling Mill Co., open-hearth iron;
N	Andrews Steel Co., copper-bearing open-hearth iron;
U or *V*	United Alloy Steel Co., open-hearth iron;
T	United Alloy Steel Co., copper-bearing open-hearth iron;
Y	Youngstown Sheet and Tube Co., open-hearth steel;
C	Youngstown Sheet and Tube Co., copper-bearing open-hearth steel;
S	American Sheet and Tin Plate Co., open-hearth steel;
K	American Sheet and Tin Plate Co., copper-bearing open-hearth steel;
W	Wrought iron.

SECOND LETTERS

A	No. 22 gage, 2½-oz. coating
B	No. 22-gage, 2-oz. coating
C	No. 22-gage, 1½-oz. coating
E	No. 22-gage, 1¼-oz. coating
H	No. 22-gage, ¾to 1-oz. coating
K	No. 28-gage, ¾to 1-oz. coating
L	No. 16-gage, 2½-oz. coating

The third letter may be one of the following: *A*, *B*, *C*, *E*, *H*, *K*, *L*, *M*, *N*, *S*, *T*, *U*, *V*, *W*, *X* or *Z*.

The sheets were stenciled on the left-hand edge and the top surface of the sheet as it went through the pot identified by the manufacturer's number. The arrangement of the stencil marks is also indicated in Fig. 5. The position of these stencil marks on the upper and lower corrugated specimens indicates whether the corrugated specimens was from the front or the list end or back of the sheet as coated. The letters at the top designate the front end, and at the bottom, the list end. After stenciling, the sheets were sheared as shown in Fig. 5.



Eight $\frac{9}{32}$"Φ Holes punched as shown on Top Center Line of Second Corrugation from each Longitudinal Edge of Specimen.

FIG. 6.—Punching Layout for A.S.T.M. 30-in. Corrugated Test Specimens.

The specimens for the accelerated tests were forwarded to the U. S. Bureau of Standards. The rack specimens were corrugated and

TABLE I.—BRUNOT ISLAND RACK. SHEET SPECIMENS EXPOSED APRIL 21, 1926. BEND TEST SPECIMENS EXPOSED DECEMBER 10, 1926.

All Values are Weights Given in Ounces per Square Foot of Sheet.

BLACK SHEETS

Code	Mfrs. No.	Whole Sheet	Top Test Section	Bottom Test Section	Top			Bottom			Maximum	Minimum	Average
					Left	Center	Right	Left	Center	Right			
UXT	13	22.19	21.56	....	21.29	21.29	21.13	....	....	....	23.08	20.80	22.01
CTT	288	21.24	21.51	....	20.92	21.23	21.07	....	....	....	21.31	19.36	20.58
YHB	339	21.19	....	21.20	....	....	....	20.63	21.28	21.29	21.29	20.23	20.70
TZT	334	22.05	21.59	....	21.09	21.30	20.69	....	....	....	22.23	20.69	21.59
VCB	...	19.46	....	19.50	....	....	....	19.62	19.64	19.82	19.82	18.39	19.24
WLB	7	21.05	....	21.18	....	....	....	20.95	21.53	21.60	21.60	19.64	20.74
KAB	269	21.50	....	21.78	....	....	....	21.25	21.78	21.28	21.78	20.75	21.20
SNB	381	21.51	....	21.56	....	....	....	21.39	21.77	21.27	21.17	21.17	21.40
NBT	2	21.92	21.89	....	21.02	22.25	21.46	....	....	....	22.31	20.42	21.36
RZT	183	21.71	21.72	....	21.18	21.46	21.62	....	....	....	21.83	21.18	21.54

GALVANIZED SHEETS

Code	Mfrs. No.	Uncoated Pickled Sheet Weight					Coated Sheet Weight							Coating Weights					
			Stripped Spot Tests							Coated Spot Tests					Triple Spot Tests				
		Whole Sheet	Top	Middle	Bottom	Average	Whole Sheet	Top Test Section	Bottom Test Section	Top	Middle	Bottom	Average	By Weight Test	Top	Middle	Bottom	Minimum	Average
KKH	27	11.39	11.01	11.55	10.74	11.10	12.15	12.21	12.15	11.82	12.31	11.54	11.89	0.76	0.81	0.76	0.80	0.76	0.79
SKK	51	11.41	11.48	11.81	9.89	11.06	12.21	12.40	12.10	12.31	12.61	10.73	11.88	0.80	0.83	0.81	0.84	0.81	0.82
YKK	T	13.26	13.62	13.62	12.61	13.16	14.52	14.43	14.26	14.07	14.51	13.77	14.11	0.90	0.80	0.89	1.16	0.80	0.95
TKE	633	12.19	12.21	12.67	11.19	12.02	12.95	13.25	12.45	12.94	13.44	12.17	12.85	0.76	0.73	0.77	0.98	0.73	0.82
NKB	30	10.59	10.68	10.48	10.62	10.60	11.44	11.44	11.63	11.63	11.41	11.60	11.55	0.85	0.95	0.92	0.98	0.92	0.95
KHT	273	21.62	20.63	21.75	21.41	21.26	22.48	22.33	22.68	21.47	22.69	22.31	22.16	0.86	0.84	0.95	0.90	0.84	0.90
CHM	287	20.86	20.25	20.65	19.30	20.07	21.67	21.78	21.18	21.28	21.53	20.24	21.01	0.81	1.03	0.88	0.93	0.88	0.95
SHV	1	21.62	21.37	21.67	21.91	21.65	22.45	22.19	22.38	22.20	22.51	22.71	22.47	0.83	0.83	0.84	0.80	0.80	0.82
YHS	472	21.52	20.62	21.63	20.87	21.04	22.33	22.27	22.05	21.65	22.44	21.94	22.01	0.81	1.04	0.82	1.07	0.82	0.98
THA	392	20.98	20.28	20.35	21.55	20.73	21.86	21.29	21.94	21.15	21.27	22.47	21.63	0.88	0.88	0.92	0.92	0.88	0.91
NHK	96	20.91	19.37	21.43	20.09	20.30	21.60	21.34	21,81	20.21	22.19	20.87	21.09	0.69	0.84	0.76	0.78	0.76	0.79
VHH	85	18.48	18.35	18.67	17.89	18.30	19.38	19.69	18.87	19.62	19.57	18.93	19.37	0.85	1.27	0.90	1.04	0.90	1.07
WEM	51	20.59	19.86	20.67	20.87	20.47	21.84	21.81	21.67	21.18	21.84	22.05	21.69	1.25	1.31	1.17	1.18	1.17	1.22
KEN	456	21.81	21.16	21.80	20.56	21.17	23.03	23.07	23.10	22.51	23.00	21.93	22.48	1.22	1.35	1.20	1.37	1.20	1.31
CET	185	21.43	20.82	21.39	20.79	21.00	22.77	22.38	22.71	22.21	22.67	22.15	22.35	1.34	1.39	1.28	1.36	1.28	1.31
SEA	437	21.80	21.38	21.91	21.33	21.54	23.09	22.79	23.21	22.71	23.19	22.63	22.85	1.29	1.34	1.29	1.30	1.29	1.30
YEC	125	21.38	21.28	21.48	19.85	20.87	22.67	22.88	22.11	22.55	22.71	21.25	22.17	1.29	1.28	1.23	1.40	1.23	1.30
TEC	440	21.57	19.46	21.21	22.91	21.19	22.77	21.83	23.43	20.85	22.42	24.22	22.50	1.20	1.39	1.21	1.31	1.21	1.34
NEL	10	20.96	20.64	21.04	19.76	20.48	22.20	22.16	22.08	21.87	22.24	21.12	21.74	1.24	1.23	1.20	1.36	1.20	1.27
VEA	70	17.81	18.09	17.56	16.81	17.49	19.15	19.26	18.84	19.69	18.90	18.56	19.05	1.34	1.60	1.34	1.75	1.34	1.57
REL	42	21.03	20.51	21.20	19.98	20.56	22.29	22.41	22.03	21.84	22.40	21.32	21.85	1.26	1.34	1.20	1.34	1.20	1.29
WCM	24	20.91	20.06	20.68	21.39	20.71	22.34	22.05	22.25	21.69	22.01	22.71	22.14	1.43	1.62	1.34	1.32	1.32	1.42
KCX	20	21.07	21.67	21.04	20.05	20.92	22.56	23.01	22.08	23.22	22.52	21.64	22.46	1.49	1.56	1.48	1.59	1.48	1.54
CCM	284	21.33	20.60	21.15	19.43	20.39	22.86	23.23	22.41	22.34	22.60	21.23	22.05	1.53	1.74	1.45	1.80	1.45	1.66
SCB	418	21.78	21.31	21.72	21.39	21.47	23.29	23.10	23.59	22.88	23.22	23.02	23.04	1.51	1.57	1.50	1.63	1.50	1.57
YCN	79	21.43	21.07	21.41	20.05	20.98	22.86	22.96	22.38	22.58	22.99	22.02	22.53	1.43	1.52	1.58	1.58	1.52	1.56
TCV	478	21.29	20.19	21.38	21.37	20.98	22.86	21.92	22.99	21.75	22.58	22.91	22.41	1.57	1.56	1.20	1.54	1.20	1.43
NCU	126	21.21	20.02	21.52	20.62	20.72	22.80	22.93	22.74	21.75	22.98	22.34	22.35	1.59	1.73	1.46	1.72	1.46	1.64
VCH	53	19.24	17.32	19.36	19.61	18.76	20.67	19.94	21.04	19.13	20.71	21.47	20.44	1.43	1.82	1.35	1.86	1.35	1.68
RCW	148	21.03	19.68	20.90	21.27	20.61	22.51	22.08	22.77	21.11	22.53	22.88	22.17	1.48	1.43	1.63	1.61	1.43	1.56
WBT	62	20.60	19.75	21.28	20.52	20.52	22.76	22.49	22.88	21.68	23.47	22.53	22.56	2.16	1.93	2.19	2.01	1.93	2.04
KBX	210	20.97	20.06	21.20	20.34	20.53	23.01	22.71	23.15	22.17	23.34	22.30	22.60	2.04	2.11	2.15	1.96	1.96	2.07
CBH	229	21.71	19.55	21.21	21.30	20.69	23.62	23.48	23.84	21.94	23.21	23.28	22.81	1.91	2.39	2.01	1.98	1.98	2.12
SBV	225	21.23	19.90	20.87	22.46	21.08	23.19	22.82	23.40	21.84	23.07	24.29	23.07	1.96	1.94	2.20	1.83	1.83	1.99
YBB	365	21.00	20.53	20.72	20.09	20.45	23.00	23.04	22.63	22.62	22.79	22.46	22.62	2.00	2.09	2.07	2.37	2.07	2.18
TBB	522	21.14	19.31	20.80	21.23	20.45	23.28	22.14	23.45	21.24	22.74	23.24	22.41	2.14	1.94	1.94	2.00	1.94	1.96
NBV	72	20.83	19.91	20.94	19.96	20.27	22.88	23.04	22.93	21.86	22.98	22.09	22.31	2.05	1.96	2.04	2.13	1.96	2.04
VBE	25	18.48	19.09	18.34	16.63	18.02	20.34	20.57	19.64	21.07	20.34	18.63	20.01	1.86	1.98	2.00	2.00	1.98	1.99
RBH	177	21.68	21.12	21.82	21.20	21.38	23.62	23.78	23.32	23.23	23.99	23.32	23.51	1.94	2.12	2.17	2.12	2.12	2.14
WAS	94	19.73	19.07	19.87	19.97	19.63	22.30	22.00	22.27	21.51	22.25	22.54	22.10	2.57	2.44	2.38	2.57	2.38	2.46
KAN	304	21.23	19.95	21.35	21.17	20.82	23.87	23.73	24.08	22.58	23.86	23.65	23.36	2.64	2.62	2.51	2.48	2.48	2.54
CAV	254	21.48	20.06	21.25	20.64	20.65	24.00	23.64	24.00	22.66	23.74	23.18	23.19	2.52	2.60	2.49	2.54	2.49	2.54
SAM	108	21.14	20.28	21.16	19.70	20.38	23.80	23.81	23.81	23.15	23.71	22.15	23.01	2.67	2.87	2.56	2.46	2.46	2.63
YAA	126	21.00	20.72	20.80	20.11	20.54	23.38	23.70	22.82	23.45	23.18	22.53	23.05	2.38	2.73	2.38	2.42	2.38	2.51
TAV	597	20.53	20.03	19.79	20.43	20.08	22.90	22.63	23.10	22.86	22.56	23.34	22.92	2.37	2.83	2.77	2.91	2.77	2.84
NAK	98	20.61	19.16	21.30	19.81	20.09	23.31	22.90	23.37	21.65	23.90	22.43	22.66	2.70	2.49	2.60	2.62	2.49	2.57
VAE	7	18.81	18.87	19.44	17.58	18.63	21.19	21.18	20.65	20.95	21.80	19.89	20.88	2.38	2.08	2.36	2.31	2.08	2.25
RAA	257	21.22	20.93	21.48	21.61	21.34	23.85	23.73	23.59	23.39	24.01	24.27	23.89	2.63	2.46	2.54	2.66	2.46	2.55
KLH	96	40.88	39.44	40.92	40.10	40.15	43.41	43.53	43.23	41.90	43.43	42.84	42.72	2.53	2.46	2.51	2.73	2.46	2.57
SLA	47	40.96	39.92	41.34	38.71	40.00	43.63	44.16	42.93	42.44	44.21	41.25	42.64	2.67	2.52	2.87	2.54	2.52	2.64
YLB	J	39.28	38.05	39.29	38.61	38.65	41.86	42.05	42.02	40.76	42.07	41.00	41.28	2.58	2.71	2.78	2.39	2.39	2.63
TLC	678	42.24	41.15	41.55	41.44	41.38	44.76	44.49	44.24	43.67	44.09	44.27	44.01	2.52	2.52	2.54	2.83	2.52	2.63
ULC	658	43.91	42.86	43.50	44.20	43.52	46.24	45.37	46.66	45.47	46.00	46.60	46.02	2.33	2.61	2.50	2.40	2.40	2.50
RLC	419	40.69	38.89	41.50	39.43	39.94	43.20	42.87	43.12	41.88	44.13	42.21	42.74	2.51	2.99	2.63	2.79	2.63	2.80

TABLE II.—ALTOONA RACK. SHEET SPECIMENS EXPOSED APRIL 22, 1926. BEND TEST SPECIMENS EXPOSED OCTOBER 22, 1926.

All Values are Weights Given in Ounces per Square Foot of Sheet.

BLACK SHEETS

Code	Mfrs. No.	Whole Sheet	Top Test Section	Bottom Test Section	Top			Bottom			Maximum	Minimum	Average
					Left	Center	Right	Left	Center	Right			
ULT	41	21.81	21.40	....	21.15	21.11	20.63	....	....	....	22.37	20.63	21.55
CLT	280	21.04	21.23	....	20.73	20.84	20.75	....	....	....	21.00	19.58	20.45
YVT	359	20.95	21.09	....	20.79	21.00	20.81	....	....	....	21.00	20.13	20.47
TBT	336	21.95	21.53	....	21.38	21.24	20.93	....	....	....	21.99	20.93	21.51
VBB	...	19.15	....	19.09	....	....	....	19.05	19.18	19.00	19.18	18.21	18.78
WHT	5	20.98	20.76	....	20.42	21.00	20.38	....	....	....	21.53	20.38	20.78
KXT	350	21.23	21.51	....	21.22	21.86	21.64	....	....	....	21.86	20.54	21.32
SXT	385	21.52	21.56	....	21.63	21.52	20.85	....	....	....	21.63	20.85	21.34
NHT	5	22.17	21.75	....	20.68	21.58	21.00	....	....	....	22.72	20.68	21.67
RKT	194	21.45	21.56	....	21.00	21.87	21.15	....	....	....	21.91	21.00	21.51

GALVANIZED SHEETS

Code	Mfrs. No.	Uncoated Pickled Sheet Weight					Coated Sheet Weight							Coating Weights					
		Whole Sheet	Stripped Spot Tests				Whole Sheet	Top Test Section	Bottom Test Section	Coated Spot Tests				By Weight Test	Triple Spot Tests				
			Top	Middle	Bottom	Average				Top	Middle	Bottom	Average		Top	Middle	Bottom	Minimum	Average
KKC	40	11.47	11.40	11.43	11.16	11.33	12.25	12.21	12.34	12.17	12.24	11.91	12.10	0.78	0.76	0.81	0.75	0.75	0.77
SKC	85	11.40	11.08	11.90	10.71	11.23	12.21	12.45	11.93	11.86	12.71	11.50	12.02	0.81	0.79	0.81	0.79	0.79	0.79
YKH	H	13.57	12.42	13.91	13.30	13.21	14.38	13.82	14.46	13.29	14.71	14.39	14.13	0.81	0.87	0.79	1.10	0.79	0.92
TKA	641	11.34	11.92	11.18	10.31	11.14	12.14	12.43	11.71	12.63	11.93	11.24	11.93	0.80	0.71	0.74	0.94	0.71	0.80
NKK	27	10.80	10.60	10.94	10.37	10.63	11.66	11.63	11.79	11.59	11.87	11.21	11.56	0.86	0.99	0.94	0.84	0.84	0.93
KHK	113	21.24	20.36	21.31	20.28	20.65	22.10	22.27	22.00	21.18	22.19	21.11	21.49	0.86	0.82	0.89	0.83	0.82	0.84
CHN	310	20.86	21.15	20.62	18.97	20.25	21.62	21.86	21.20	22.13	21.43	19.88	21.15	0.76	0.98	0.81	0.92	0.81	0.90
SHE	356	21.87	21.52	22.18	21.75	21.81	22.65	22.88	22.57	22.34	22.95	22.49	22.59	0.78	0.82	0.77	0.74	0.74	0.78
YHC	415	20.62	19.78	20.50	20.58	20.29	21.48	21.04	21.53	20.85	21.49	21.37	21.23	0.86	1.07	0.98	0.78	0.78	0.94
THK	384	21.02	20.09	20.98	20.88	20.65	21.81	21.40	21.89	21.05	21.71	21.69	21.48	0.79	0.97	0.72	0.81	0.72	0.83
NHH	133	20.66	18.76	20.82	21.07	20.21	21.34	20.82	21.86	19.48	21.58	21.73	20.93	0.68	0.73	0.76	0.66	0.66	0.72
VHC	81	16.48	15.98	16.47	16.07	16.17	17.38	17.56	17.09	16.89	17.48	17.13	17.11	0.90	0.91	1.01	0.96	0.91	0.96
WEN	50	20.05	19.03	20.35	20.78	20.05	21.24	20.96	21.23	20.36	21.41	21.93	21.23	1.19	1.33	1.05	1.15	1.05	1.18
KEL	459	20.69	19.89	21.01	20.34	20.41	21.90	21.59	22.03	21.21	22.25	21.59	21.68	1.21	1.32	1.23	1.25	1.23	1.27
CEC	322	21.62	20.58	21.32	20.43	20.78	22.86	22.79	22.60	22.11	22.46	21.72	22.09	1.24	1.53	1.13	1.28	1.14	1.32
SEW	150	21.62	19.75	21.65	21.50	20.97	22.86	22.30	23.51	21.02	22.95	22.73	22.23	1.24	1.27	1.30	1.23	1.23	1.27
YEA	91	21.05	20.12	21.48	19.82	20.47	22.24	22.25	21.83	21.35	22.56	21.10	21.68	1.19	1.26	1.08	1.28	1.08	1.21
TEN	418	21.38	19.65	21.40	21.82	20.96	22.58	21.94	22.79	21.13	22.57	23.06	22.25	1.20	1.47	1.17	1.23	1.17	1.29
NES	3	20.66	19.73	21.11	19.95	20.26	21.94	21.81	22.03	21.02	22.34	21.07	21.48	1.28	1.29	1.23	1.11	1.11	1.21
VEB	66	19.42	19.44	19.49	18.50	19.14	20.72	21.09	20.13	21.09	20.70	19.80	20.53	1.30	1.66	1.21	1.29	1.21	1.39
REW	68	20.84	19.47	20.76	21.19	20.47	22.02	21.67	22.33	20.66	22.07	22.51	21.75	1.18	1.19	1.31	1.33	1.19	1.28
WCA	28	20.58	19.50	20.64	20.36	20.16	22.06	21.78	22.05	21.12	21.92	21.75	21.59	1.48	1.63	1.28	1.38	1.28	1.43
KCB	460	21.90	20.74	22.60	21.08	21.47	23.35	23.26	23.26	22.35	24.12	22.52	22.99	1.45	1.60	1.52	1.44	1.44	1.52
CCB	267	21.19	20.65	20.91	20.15	20.57	22.71	22.77	22.33	22.47	22.24	21.79	22.16	1.52	1.82	1.33	1.64	1.33	1.60
SCE	410	21.36	21.55	21.53	20.28	21.12	22.85	23.04	22.79	23.06	23.04	21.77	22.62	1.49	1.52	1.51	1.49	1.49	1.50
YCK	74	21.76	20.93	21.69	20.95	21.19	23.24	22.82	23.26	22.64	23.20	22.39	22.74	1.48	1.71	1.52	1.44	1.44	1.56
TCL	465	20.76	19.83	20.88	20.37	20.36	22.19	21.34	22.30	21.35	22.14	21.85	21.78	1.43	1.52	1.26	1.47	1.26	1.42
NCX	138	20.87	19.84	20.98	20.65	20.49	22.33	22.25	22.52	21.61	22.38	22.28	22.09	1.46	1.77	1.40	1.63	1.40	1.60
VCB	45	19.34	19.69	19.08	18.23	19.00	20.76	21.23	20.24	21.32	20.36	19.87	20.52	1.42	1.63	1.28	1.64	1.28	1.52
RCX	145	20.76	19.87	20.50	21.30	20.56	22.25	21.75	22.49	21.38	22.02	22.85	22.08	1.49	1.51	1.52	1.55	1.51	1.53
WBS	60	19.95	18.65	20.09	20.35	19.70	21.92	21.34	22.25	20.37	22.01	22.33	21.57	1.97	1.72	1.92	1.98	1.72	1.87
KBN	474	21.81	20.67	22.16	21.04	21.29	23.81	23.86	23.62	22.69	24.20	22.87	23.25	2.00	2.02	2.04	1.83	1.83	1.96
CBA	231	21.43	20.04	21.62	21.29	20.98	23.47	23.70	23.29	22.26	23.53	23.30	23.03	2.04	2.22	1.91	2.01	1.91	2.05
SBC	413	21.79	21.48	21.82	21.65	21.65	23.85	23.75	23.92	23.44	23.92	23.56	23.64	2.06	1.96	2.10	1.90	1.90	1.99
YBX	131	21.05	20.39	21.24	19.61	20.41	23.00	23.12	22.47	22.56	23.35	21.65	22.52	1.95	2.18	2.10	2.05	2.05	2.11
TBW	502	20.91	19.10	20.96	21.11	20.39	22.86	21.83	23.40	21.11	22.80	23.01	22.31	1.95	2.01	1.84	1.90	1.84	1.91
NBU	61	20.96	20.17	20.82	20.34	20.44	22.97	22.82	22.99	22.20	22.83	22.32	22.45	2.01	2.04	2.01	1.99	1.99	2.01
VBA	33	19.09	18.70	19.28	17.70	18.56	21.05	21.20	20.55	20.67	21.19	19.58	20.48	1.96	1.97	1.91	1.89	1.89	1.92
RBE	167	20.72	20.86	20.75	20.11	20.57	22.63	23.07	22.19	22.97	22.76	21.99	22.57	1.91	2.11	2.01	1.88	1.88	2.00
WAL	96	20.36	19.34	20.32	20.55	20.07	23.00	22.74	22.96	21.73	22.94	23.06	22.58	2.64	2.39	2.62	2.51	2.39	2.51
KAA	496	21.73	20.73	22.51	21.44	21.56	24.25	24.06	24.22	23.11	25.20	23.78	24.03	2.52	2.39	2.69	2.34	2.34	2.47
CAE	260	21.43	19.34	21.22	20.34	20.30	24.05	23.56	24.25	21.80	23.68	22.95	22.81	2.62	2.46	2.46	2.61	2.46	2.51
SAS	125	20.80	20.30	21.35	19.58	20.41	23.32	23.34	23.18	23.14	23.75	22.11	23.00	2.52	2.85	2.40	2.53	2.40	2.59
YAT	402	21.76	20.29	21.93	21.25	21.16	24.10	23.81	24.06	22.75	24.33	23.78	23.62	2.34	2.47	2.39	2.53	2.39	2.46
TAH	581	21.94	22.14	21.09	19.77	21.00	23.95	24.63	23.10	24.91	23.93	22.57	23.80	2.01	2.77	2.83	2.80	2.77	2.80
NAS	97	21.38	19.14	21.97	21.50	20.87	23.87	23.04	24.63	21.65	24.64	23.96	23.42	2.49	2.52	2.67	2.46	2.46	2.55
VAC	12	18.62	17.91	18.47	18.97	18.45	20.95	20.60	21.12	20.08	20.64	21.29	20.67	2.33	2.17	2.17	2.32	2.17	2.22
RAT	297	20.88	19.66	21.05	20.62	20.44	23.39	23.48	23.43	22.26	23.50	23.15	22.97	2.51	2.59	2.45	2.54	2.45	2.53
KLM	145	39.54	37.70	40.06	37.55	38.43	42.06	42.57	41.69	40.14	42.52	40.23	40.96	2.52	2.44	2.46	2.68	2.44	2.53
SLE	50	40.58	40.03	40.49	38.75	39.76	43.21	43.70	42.87	42.46	43.30	41.25	42.34	2.63	2.43	2.81	2.50	2.43	2.58
YLC	K	39.43	38.64	39.06	38.68	38.79	41.90	42.24	42.08	41.22	41.76	41.04	41.34	2.47	2.58	2.70	2.36	2.36	2.55
TLK	684	40.33	39.62	38.92	41.14	39.90	42.77	41.72	42.98	42.08	41.28	43.81	42.39	2.44	2.46	2.36	2.67	2.36	2.50
ULM	655	42.09	43.24	41.78	41.22	42.08	44.43	45.15	43.37	45.82	44.16	43.58	44.52	2.34	2.59	2.38	2.36	2.36	2.44

TABLE III.—STATE COLLEGE RACK. SHEET SPECIMENS EXPOSED APRIL 23, 1926.
BEND TEST SPECIMENS EXPOSED OCTOBER 26, 1926.

All Values are Weights Given in Ounces per Square Foot of Sheet.

BLACK SHEETS

Code	Mfrs. No.	Whole Sheet	Top Test Section	Bottom Test Section	Top			Bottom			Maximum	Minimum	Average
					Left	Center	Right	Left	Center	Right			
USB	22	22.05	....	21.31	....	....	....	21.51	21.16	21.30	22.72	21.16	21.97
CMT	285	21.24	21.15	....	20.75	20.98	20.88	....	....	....	21.18	19.97	20.70
YWT	368	21.19	21.04	....	20.99	21.15	21.09	....	....	....	21.15	20.62	20.89
TNT	323	22.00	21.51	....	21.19	21.07	21.10	....	....	....	22.29	21.07	21.62
VET	...	18.94	19.06	....	18.88	18.51	18.79	....	....	....	18.88	18.21	18.46
WBB	2	21.02	....	20.93	....	....	....	20.50	20.96	20.53	21.32	20.01	20.68
KNT	357	21.46	22.03	....	21.24	21.52	21.20	....	....	....	21.89	19.84	20.96
SCT	390	21.45	21.51	....	21.02	21.37	21.33	....	....	....	21.85	21.02	21.40
NET	4	21.94	21.56	....	20.19	21.64	21.14	....	....	....	22.24	20.19	21.36
RBB	198	21.33	....	21.40	....	....	....	21.66	21.23	21.33	21.76	20.50	21.38

GALVANIZED SHEETS

Code	Mfrs. No.	Uncoated Pickled Sheet Weight					Coated Sheet Weight							Coating Weights					
			Stripped Spot Tests							Coated Spot Tests					Triple Spot Tests				
		Whole Sheet	Top	Middle	Bottom	Average	Whole Sheet	Top Test Section	Bottom Test Section	Top	Middle	Bottom	Average	By Weight Test	Top	Middle	Bottom	Minimum	Average
KKK	3	11.50	11.02	11.60	11.33	11.31	12.26	12.12	12.34	11.82	12.35	12.06	12.07	0.76	0.80	0.76	0.73	0.73	0.76
SKA	60	11.22	10.88	11.44	11.01	11.11	12.02	12.07	11.99	11.71	12.22	11.78	11.90	0.80	0.83	0.78	0.76	0.76	0.79
YKM	S	13.62	13.32	13.55	12.91	13.26	14.43	14.26	14.15	14.07	14.33	13.96	14.12	0.81	0.75	0.78	1.06	0.75	0.86
TKM	644	12.00	11.71	12.21	11.19	11.70	12.76	12.59	12.75	12.44	12.93	12.12	12.50	0.76	0.72	0.72	0.93	0.72	0.79
NKH	28	10.89	10.83	11.16	10.44	10.81	11.74	11.82	11.79	11.77	12.14	11.25	11.72	0.85	0.94	0.98	0.81	0.81	0.91
KHC	116	20.96	20.97	21.43	20.16	20.85	21.79	22.05	21.45	21.75	22.31	21.04	21.70	0.83	0.78	0.87	0.88	0.78	0.84
CHA	319	21.33	21.15	21.14	19.66	20.65	22.14	21.97	21.92	22.02	21.97	20.41	21.47	0.81	0.87	0.84	0.75	0.75	0.82
SHC	361	21.76	21.69	22.02	21.30	21.67	22.54	22.68	22.33	22.43	22.82	22.08	22.44	0.78	0.74	0.80	0.79	0.74	0.77
YHH	461	21.05	20.21	21.07	20.46	20.58	21.86	21.53	21.97	20.12	21.95	21.41	21.49	0.81	0.91	0.88	0.95	0.88	0.91
THS	281	21.10	20.68	20.87	21.00	20.85	21.86	21.51	21.86	21.66	21.59	21.78	21.67	0.76	0.97	0.71	0.78	0.71	0.82
NHA	136	21.68	20.61	21.91	21.31	21.27	22.28	22.38	22.27	21.33	22.56	22.02	21.97	0.60	0.72	0.65	0.72	0.65	0.70
VHE	87	17.86	17.87	17.52	17.51	17.63	18.77	18.76	18.57	18.75	18.40	18.36	18.50	0.91	0.88	0.88	0.86	0.86	0.87
WET	45	20.07	19.02	20.00	20.18	19.73	21.28	20.90	21.34	20.20	21.18	21.33	20.91	1.21	1.18	1.18	1.16	1.16	1.17
KEW	134	21.65	21.30	21.74	20.94	21.33	22.82	22.74	22.93	22.66	22.91	22.18	22.58	1.17	1.35	1.17	1.24	1.17	1.25
CEL	321	21.38	20.18	21.04	20.14	20.45	22.58	22.22	22.41	21.56	22.11	21.29	21.65	1.20	1.38	1.08	1.15	1.08	1.20
SEX	133	21.44	21.84	21.54	20.96	21.45	22.61	22.93	22.47	23.00	22.75	22.15	22.63	1.17	1.16	1.21	1.19	1.16	1.19
YEX	337	21.10	20.13	20.81	20.52	20.48	22.33	22.14	22.00	21.46	21.85	21.62	21.64	1.23	1.33	1.04	1.10	1.04	1.16
TEK	421	21.71	22.86	21.64	20.13	21.55	22.96	23.34	21.92	24.19	22.76	21.34	22.76	1.25	1.32	1.11	1.21	1.11	1.22
NEU	6	20.70	19.66	20.89	20.42	20.32	21.98	21.67	22.16	20.91	22.13	21.50	21.51	1.28	1.26	1.24	1.08	1.08	1.19
VEH	75	19.53	19.55	19.35	19.37	19.42	20.86	21.04	20.74	21.00	20.44	20.77	20.74	1.33	1.45	1.10	1.40	1.10	1.32
RET	62	21.03	20.97	20.93	20.40	20.77	22.21	22.55	21.81	22.24	22.08	21.75	22.02	1.18	1.28	1.15	1.35	1.15	1.26
WCK	49	20.26	19.43	20.88	19.76	20.03	21.66	21.67	21.45	20.97	22.17	21.15	21.43	1.40	1.54	1.29	1.39	1.29	1.41
KCN	473	21.85	21.17	22.34	20.59	21.36	23.30	23.32	23.10	22.73	23.80	22.06	22.86	1.45	1.57	1.46	1.47	1.46	1.50
CCC	306	21.24	20.37	20.92	19.99	20.43	22.81	22.85	22.71	22.00	22.24	21.69	21.98	1.57	1.63	1.33	1.70	1.33	1.55
SCL	110	21.42	21.39	21.57	21.12	21.36	22.90	22.90	22.63	22.91	22.98	22.64	22.84	1.48	1.52	1.41	1.52	1.41	1.48
YCA	54	21.24	20.33	21.09	20.09	20.50	22.67	22.71	22.52	21.95	22.60	21.57	22.04	1.43	1.62	1.51	1.48	1.48	1.54
TCX	483	21.14	19.95	21.15	20.75	20.62	22.58	21.94	22.44	21.53	22.40	22.15	22.03	1.44	1.58	1.25	1.40	1.25	1.41
NCA	37	21.86	19.85	22.48	21.07	21.13	23.36	23.18	23.40	21.49	24.06	22.49	22.68	1.50	1.65	1.58	1.42	1.42	1.55
VCC	52	19.76	19.35	19.77	20.01	19.71	21.19	21.04	21.42	20.87	20.99	21.81	21.22	1.43	1.53	1.23	1.80	1.23	1.52
RCZ	149	20.76	20.31	20.67	19.95	20.31	22.17	22.49	22.83	21.84	22.15	21.46	21.82	1.41	1.52	1.49	1.51	1.49	1.51
WBC	80	20.59	20.00	21.10	20.24	20.44	22.71	22.52	22.55	21.97	23.20	22.41	22.53	2.12	1.97	2.10	2.17	1.97	2.08
KBT	228	21.24	21.57	21.10	21.04	21.24	23.25	23.51	22.99	23.46	23.20	22.92	23.19	2.01	1.89	2.10	1.88	1.88	1.96
CBB	236	21.33	19.97	21.19	20.58	20.58	23.19	23.04	23.04	22.15	23.07	22.58	22.60	1.86	2.18	1.88	2.00	1.88	2.02
SBT	190	21.22	20.74	21.04	21.58	20.79	23.27	23.12	23.40	22.62	23.19	23.50	23.10	2.05	1.88	2.15	1.92	1.88	1.98
YBU	51	21.62	20.20	21.87	20.43	20.84	23.53	23.23	23.23	22.48	23.78	22.4[illegible]	22.89	1.91	2.28	1.91	1.99	1.91	2.06
TBM	506	20.95	19.54	20.94	20.87	20.45	23.00	22.41	23.04	21.44	22.81	22.81	22.35	2.05	1.90	1.87	1.93	1.87	1.90
NBT	63	21.21	19.72	21.72	20.69	20.71	23.31	23.23	23.45	21.68	23.76	22.64	22.69	2.10	1.95	2.05	1.95	1.95	1.98
VBC	31	19.05	19.10	18.99	18.26	18.78	20.95	20.98	20.65	21.02	20.80	20.13	20.65	1.90	1.92	1.81	1.86	1.81	1.86
RBX	234	21.60	22.19	21.62	20.95	21.59	23.58	23.56	23.21	24.24	23.53	22.84	23.54	1.98	2.05	1.91	1.89	1.89	1.95
WAE	91	20.48	19.34	20.95	19.79	20.03	23.19	22.90	23.45	22.28	23.46	22.51	22.75	2.71	2.94	2.50	2.72	2.50	2.72
KAM	286	21.21	21.16	21.24	20.02	20.81	23.66	23.75	23.37	23.73	23.76	22.32	23.27	2.45	2.58	2.51	2.30	2.30	2.46
CAH	257	21.43	19.36	21.54	20.48	20.46	23.81	23.37	23.89	21.87	23.96	22.84	22.89	2.38	2.51	2.43	2.36	2.36	2.43
SAW	148	20.94	20.44	20.66	19.90	20.33	23.57	23.89	23.43	23.17	23.20	22.35	22.91	2.64	2.74	2.54	2.45	2.45	2.58
YAC	115	21.10	20.67	21.12	19.63	20.47	23.47	23.53	22.96	23.23	23.43	22.14	22.93	2.39	2.56	2.31	2.51	2.31	2.46
TAX	554	20.19	19.61	19.84	19.20	19.55	22.71	22.68	22.33	22.44	22.56	22.03	22.34	2.52	2.82	2.71	2.83	2.71	2.79
NAT	85	21.43	21.08	21.63	20.13	20.95	23.96	24.14	23.67	23.57	24.16	22.72	23.49	2.53	2.49	2.53	2.60	2.49	2.54
VAA	14	19.24	19.99	19.05	18.70	19.25	21.57	21.92	20.79	22.37	21.27	20.77	21.47	2.33	2.38	2.22	2.07	2.07	2.22
RAH	267	20.80	20.70	20.32	20.54	20.52	23.39	23.70	23.26	23.12	22.89	23.07	23.03	2.59	2.42	2.57	2.53	2.42	2.51
KLE	89	40.85	39.50	41.02	39.94	40.15	43.36	43.56	43.23	41.88	43.49	42.51	42.63	2.51	2.37	2.47	2.58	2.37	2.48
SLM	1	39.53	39.38	39.30	38.47	39.05	42.12	42.24	41.86	41.80	42.01	40.93	41.58	2.59	2.42	2.71	2.47	2.42	2.53
YLK	A	40.14	39.74	40.50	39.34	39.86	42.57	42.65	42.74	41.99	42.91	41.89	42.26	2.43	2.25	2.40	2.55	2.25	2.40
TLM	683	41.76	41.92	41.82	38.76	40.83	44.19	44.63	42.60	44.36	44.20	41.37	43.31	2.43	2.45	2.38	2.61	2.38	2.48
ULK	654	43.15	42.83	42.11	43.61	42.85	45.52	44.90	46.08	45.23	44.58	46.03	45.28	2.37	2.40	2.47	2.42	2.40	2.43
RLA	418	40.61	39.70	40.99	40.07	40.26	43.01	43.07	42.61	42.62	43.67	42.71	43.00	2.40	2.92	2.67	2.64	2.64	2.74

TABLE IV.—SANDY HOOK RACK. SHEET SPECIMENS EXPOSED MAY 20, 1926. BEND TEST SPECIMENS EXPOSED OCTOBER 15, 1926.

All Values are Weights Given in Ounces per Square Foot of Sheet.

BLACK SHEETS

Code	Mfrs. No.	Whole Sheet	Top Test Section	Bottom Test Section	Top			Bottom			Maximum	Minimum	Average
					Left	Center	Right	Left	Center	Right			
UBT	42	22.10	21.53	....	21.38	21.78	21.61	....	....	....	22.73	21.38	21.89
CBT	268	21.29	21.37	....	21.45	21.54	21.45	....	....	....	21.54	19.81	20.91
YZB	367	21.38	....	21.15	....	....	....	20.74	20.85	20.90	21.03	20.74	20.90
TVT	330	21.33	21.56	....	21.48	21.76	21.39	....	....	....	21.76	20.48	21.14
VAT	...	20.16	19.39	....	18.94	19.51	19.90	....	....	....	21.31	18.94	20.14
WKB	6	20.69	....	20.68	....	....	....	20.99	21.29	20.99	21.29	19.91	20.64
KST	358	21.70	21.53	....	21.12	21.74	21.30	....	....	....	21.87	20.76	21.32
SST	384	21.55	21.56	....	21.42	21.51	21.24	....	....	....	21.78	20.82	21.32
NBB	2	21.92	....	21.78	....	....	....	20.42	21.12	20.68	22.31	20.42	21.36
RZB	183	21.71	....	21.67	....	....	....	21.34	21.43	21.43	21.83	21.18	21.54

GALVANIZED SHEETS

Code	Mfrs. No.	Uncoated Pickled Sheet Weight					Coated Sheet Weight							Coating Weights					
			Stripped Spot Tests							Coated Spot Tests					Triple Spot Tests				
		Whole Sheet	Top	Middle	Bottom	Average	Whole Sheet	Top Test Section	Bottom Test Section	Top	Middle	Bottom	Average	By Weight Test	Top	Middle	Bottom	Minimum	Average
KKA	17	11.20	10.56	11.21	10.76	10.85	11.98	11.85	12.12	11.40	12.00	11.51	11.64	0.78	0.84	0.79	0.75	0.75	0.79
SKE	68	11.49	10.87	11.97	11.26	11.37	12.27	12.15	12.23	11.71	12.77	12.07	12.19	0.78	0.84	0.80	0.81	0.80	0.82
YKC	0	13.90	12.58	14.21	13.43	13.41	14.71	14.54	14.54	13.65	15.01	14.35	14.34	0.81	1.08	0.80	0.92	0.80	0.93
TKC	647	11.05	10.30	10.85	11.51	10.89	11.81	11.19	12.34	11.10	11.57	12.38	11.68	0.76	0.80	0.72	0.87	0.72	0.80
NKL	21	11.01	10.95	11.46	10.17	10.86	11.91	12.01	11.88	11.86	12.31	11.24	11.80	0.90	0.91	0.85	1.07	0.85	0.95
KHS	238	21.49	20.99	21.37	20.38	20.91	22.38	22.52	22.33	21.85	22.27	21.28	21.80	0.89	0.85	0.90	0.90	0.85	0.88
CHU	301	21.33	20.22	20.96	19.95	20.38	22.24	22.27	22.25	21.13	21.81	20.95	21.29	0.91	0.91	0.85	1.00	0.85	0.92
SHA	355	21.87	21.91	21.68	21.78	21.79	22.66	22.79	22.52	22.69	22.50	22.57	22.59	0.79	0.78	0.82	0.80	0.78	0.80
YHM	469	21.10	20.06	21.19	20.35	20.53	21.90	21.78	21.93	20.97	22.08	21.48	21.51	0.80	0.91	0.89	1.13	0.89	0.98
THN	377	21.28	19.81	21.50	20.90	20.74	22.14	21.45	22.22	20.84	22.33	21.88	21.68	0.86	1.03	0.83	0.98	0.83	0.95
NHX	135	21.47	19.82	21.90	20.20	20.64	22.20	22.14	19.53	20.63	22.67	20.92	21.41	0.73	0.81	0.77	0.72	0.72	0.77
VHA	86	18.05	17.29	17.63	17.84	17.59	19.00	18.98	19.01	18.45	18.60	18.78	18.61	0.95	1.16	0.96	0.94	0.94	1.02
WEC	44	20.12	19.51	20.64	19.95	20.03	21.38	21.12	21.34	20.88	21.79	21.11	21.26	1.26	1.37	1.15	1.15	1.15	1.22
KES	463	21.86	21.37	21.87	21.27	21.50	23.07	23.21	23.07	22.74	23.05	22.56	22.78	1.21	1.37	1.18	1.29	1.18	1.28
CEX	202	21.76	19.83	21.53	21.41	20.92	22.96	22.74	23.15	21.24	22.78	22.77	22.26	1.20	1.40	1.26	1.37	1.26	1.34
SEV	121	21.33	20.99	21.64	19.48	20.70	22.53	22.60	22.52	22.24	22.96	20.80	22.00	1.20	1.25	1.32	1.32	1.25	1.30
YEW	326	21.43	20.83	21.23	20.49	20.85	22.67	22.55	22.38	22.45	22.31	21.73	22.16	1.24	1.62	1.08	1.25	1.08	1.31
TEV	408	21.05	19.06	21.29	22.21	20.85	22.29	21.12	22.93	22.43	22.42	23.59	22.15	1.24	1.38	1.13	1.38	1.13	1.30
NEV	20	21.30	20.27	21.87	21.32	21.15	22.54	22.30	22.47	21.50	23.19	22.53	22.41	1.24	1.24	1.32	1.22	1.22	1.26
VEC	62	19.09	18.03	18.74	18.64	18.47	20.34	20.16	20.52	19.46	20.14	20.19	19.93	1.25	1.43	1.40	1.54	1.40	1.46
REK	41	21.49	21.06	21.59	20.78	21.14	22.70	22.68	22.60	21.35	22.82	22.11	22.43	1.21	1.29	1.23	1.33	1.23	1.28
WCS	20	19.85	18.64	19.87	19.70	19.40	21.28	20.85	21.26	20.17	21.14	21.09	20.80	1.43	1.53	1.27	1.39	1.27	1.40
KCS	471	21.75	21.02	22.58	21.29	21.63	23.23	23.12	23.01	22.62	24.07	22.78	23.15	1.48	1.60	1.49	1.48	1.48	1.52
CCX	297	21.14	20.79	21.03	19.53	20.45	22.62	22.85	22.16	22.59	22.38	21.19	22.05	1.48	1.80	1.35	1.65	1.35	1.60
SCA	411	21.81	21.00	22.11	20.67	21.26	23.34	23.29	23.40	22.61	23.64	22.19	22.81	1.53	1.61	1.53	1.52	1.52	1.56
YCL	78	21.19	21.28	21.02	20.22	20.84	22.71	22.88	22.14	22.87	22.57	21.74	22.39	1.52	1.60	1.55	1.53	1.53	1.56
TCT	475	20.72	20.12	20.61	20.74	20.49	22.19	21.45	22.36	21.61	21.89	22.26	21.92	1.47	1.49	1.28	1.52	1.28	1.43
NCL	110	21.30	19.91	21.54	21.85	21.10	22.80	22.27	23.45	21.61	22.98	23.52	22.70	1.50	1.70	1.44	1.68	1.44	1.61
VCA	50	19.00	18.26	19.16	18.90	18.77	20.43	20.11	20.60	19.93	20.39	20.63	20.32	1.43	1.67	1.23	1.74	1.23	1.54
RCL	119	20.76	19.91	20.61	20.48	20.33	22.17	21.97	22.25	21.40	22.22	22.08	21.90	1.41	1.49	1.62	1.60	1.49	1.57
WBE	82	21.28	20.16	21.75	21.76	21.23	23.29	23.01	23.29	22.05	23.82	23.78	23.21	2.01	1.89	2.07	2.10	1.89	2.02
KBS	216	21.24	20.15	21.42	21.08	20.88	23.28	22.90	23.56	22.22	23.49	23.03	22.91	2.04	2.07	2.07	1.95	1.95	2.03
CBZ	228	21.62	19.78	21.43	21.17	20.79	23.53	22.79	23.75	22.07	23.45	23.01	22.84	1.91	2.29	2.03	1.84	1.84	2.05
SBX	215	20.90	20.35	21.16	20.47	20.66	22.91	22.99	22.60	22.18	23.36	22.41	22.65	2.01	1.83	2.20	1.94	1.83	1.99
YBV	50	21.71	20.69	21.85	20.85	21.13	23.57	23.40	23.34	23.09	23.85	22.96	23.30	1.86	2.40	2.00	2.11	2.00	2.17
TBA	548	21.48	20.31	21.24	21.46	21.00	23.47	22.71	23.51	22.31	23.14	23.40	22.95	1.99	2.00	1.91	1.94	1.91	1.95
NBH	64	21.26	20.00	21.75	20.09	20.61	23.23	23.04	23.15	22.12	23.74	22.04	22.63	1.97	2.12	1.98	1.96	1.96	2.02
VBB	34	16.95	16.41	17.11	15.96	16.49	18.86	18.82	18.43	18.39	19.17	17.72	18.42	1.91	1.98	2.06	1.75	1.75	1.93
RBV	239	21.07	21.06	21.03	20.72	20.93	23.09	22.79	22.90	23.16	22.98	22.72	22.95	2.02	2.10	1.95	2.00	1.95	2.02
WAT	86	19.19	18.63	19.29	18.91	18.94	21.77	21.61	21.59	21.30	21.82	21.38	21.50	2.58	2.68	2.53	2.47	2.47	2.56
KAZ	278	21.14	20.19	21.31	20.25	20.58	23.67	23.73	23.62	22.51	23.86	22.96	23.11	2.53	2.32	2.55	2.71	2.32	2.53
CAM	255	21.52	19.86	21.68	20.56	20.70	24.10	23.62	24.08	22.60	23.93	23.11	23.21	2.58	2.74	2.24	2.56	2.24	2.51
SAL	119	21.17	20.90	21.60	19.96	20.82	23.76	23.81	23.59	23.67	24.19	22.47	23.44	2.59	2.77	2.59	2.51	2.51	2.62
YAV	112	21.24	20.33	20.84	19.98	20.38	23.62	23.78	23.12	22.89	23.29	22.44	22.87	2.38	2.56	2.45	2.46	2.45	2.49
TAU	553	20.34	18.57	19.39	20.20	19.38	22.77	21.53	23.32	21.38	22.34	23.17	22.30	2.43	2.81	2.95	2.98	2.81	2.91
NAU	78	20.53	19.87	20.71	19.59	20.06	23.14	23.32	22.93	22.50	23.29	22.04	22.61	2.61	2.63	2.59	2.45	2.45	2.56
VAH	4	19.19	18.35	19.43	18.33	18.71	21.52	21.18	21.45	20.63	21.70	20.45	20.93	2.33	2.28	2.27	2.12	2.12	2.22
RAC	264	21.37	20.95	21.28	21.81	21.35	23.85	23.51	24.30	23.56	23.84	24.25	23.88	2.48	2.62	2.56	2.43	2.43	2.53
KLA	139	40.53	38.96	40.83	39.40	39.73	43.11	42.85	43.15	41.38	43.32	42.18	42.30	2.58	2.43	2.50	2.78	2.43	2.57
SLB	77	39.54	39.47	39.70	37.10	38.75	42.19	42.60	41.72	42.04	42.36	39.77	41.39	2.65	2.57	2.66	2.67	2.57	2.63
YLE	E	40.19	38.03	40.16	38.89	39.02	42.71	42.41	43.01	40.84	42.70	41.27	41.60	2.52	2.81	2.54	2.38	2.38	2.58
TLB	681	40.67	39.72	39.84	39.94	39.80	43.15	42.11	43.45	42.00	42.30	42.63	42.31	2.48	2.48	2.36	2.69	2.36	2.51
ULB	657	42.86	42.74	42.56	43.23	42.84	45.33	42.03	45.42	45.38	44.91	45.62	45.30	2.47	2.64	2.36	2.39	2.36	2.46
RLB	412	40.80	39.18	42.08	39.96	40.41	43.43	43.01	43.28	41.88	44.74	42.89	43.17	2.63	2.70	2.66	2.94	2.66	2.76

TABLE V.—KEY WEST RACK. SHEET SPECIMENS EXPOSED JUNE 11, 1926. BEND TEST SPECIMENS EXPOSED NOVEMBER 8, 1926.

All Values are Weights Given in Ounces per Square Foot of Sheet.

BLACK SHEETS

Code	Mfrs. No.	Whole Sheet	Top Test Section	Bottom Test Section	Top			Bottom			Maximum	Minimum	Average
					Left	Center	Right	Left	Center	Right			
UVB	19	21.81	....	21.70	....	....	....	21.22	21.56	21.23	22.30	20.00	21.23
CUT	291	21.38	21.53	....	20.83	21.17	21.11	....	....	....	21.90	18.86	20.65
YZT	367	21.38	21.23	....	20.78	21.01	21.02	....	....	....	21.03	20.74	20.90
TLB	346	21.00	....	21.59	....	....	....	22.20	21.60	21.41	22.20	19.27	20.64
VAB	...	20.16	....	20.57	....	....	....	20.95	21.22	21.31	21.31	18.94	20.14
WAB	1	21.12	....	21.26	....	....	....	20.96	21.84	21.51	21.84	19.46	20.75
KVT	364	21.52	21.92	....	21.49	21.61	21.50	....	....	....	21.94	20.61	21.23
SUT	378	21.47	21.59	....	21.83	21.17	21.72	....	....	....	21.83	20.76	21.45
NKT	6	22.16	21.94	....	20.86	22.01	21.23	....	....	....	22.59	20.86	21.61
RKB	194	21.45	....	21.75	....	....	....	21.39	21.55	21.57	21.91	21.00	21.51

GALVANIZED SHEETS

Code	Mfrs. No.	Uncoated Pickled Sheet Weight					Coated Sheet Weight							Coating Weights					
			Stripped Spot Tests							Coated Spot Tests					Triple Spot Tests				
		Whole Sheet	Top	Middle	Bottom	Average	Whole Sheet	Top Test Section	Bottom Test Section	Top	Middle	Bottom	Average	By Weight Test	Top	Middle	Bottom	Minimum	Average
KKB	47	11.39	11.05	11.70	11.29	11.35	12.18	12.10	12.26	11.87	12.50	12.07	12.14	0.79	0.81	0.80	0.78	0.78	0.80
SKL	62	11.55	11.31	11.81	11.11	11.41	12.36	12.45	12.21	12.18	12.62	11.92	12.24	0.81	0.88	0.81	0.81	0.81	0.83
YKE	D	13.95	12.39	14.43	13.39	13.40	14.86	14.57	14.73	13.52	15.41	14.29	14.41	0.90	1.13	0.98	0.90	0.90	1.00
TKL	645	12.05	11.44	11.94	11.52	11.63	12.81	12.43	12.78	12.30	12.70	12.42	12.47	0.76	0.87	0.76	0.89	0.76	0.84
NKC	25	11.19	10.66	11.40	11.00	11.02	12.09	11.93	12.34	11.64	12.31	12.01	11.99	0.90	0.98	0.91	1.01	0.91	0.97
KHX	86	21.18	20.97	21.51	20.39	20.96	22.07	22.25	21.78	21.90	22.43	21.27	21.87	0.89	0.93	0.92	0.88	0.88	0.91
CHT	275	21.00	20.45	20.94	19.66	20.35	21.86	21.92	21.67	21.49	21.85	20.56	21.30	0.86	1.04	0.91	0.90	0.90	0.95
SHT	8	21.29	20.27	21.57	20.20	20.68	22.13	21.75	22.27	21.10	22.43	21.06	21.53	0.84	0.83	0.86	0.87	0.83	0.85
YHN	471	21.10	19.76	21.80	20.29	20.62	21.95	21.89	21.72	20.76	22.74	21.32	21.61	0.85	1.00	0.94	1.03	0.94	0.99
THH	385	21.59	20.33	21.67	21.91	21.31	22.43	21.81	22.68	21.44	22.49	22.72	22.22	0.84	1.11	0.82	0.81	0.81	0.91
NHB	116	20.66	19.33	21.28	20.54	20.38	21.43	21.07	21.61	20.14	22.06	21.40	21.20	0.77	0.81	0.78	0.86	0.78	0.82
VHB	84	19.00	18.74	18.91	18.80	18.82	19.91	20.16	19.56	20.25	19.85	19.63	19.91	0.91	1.51	0.94	0.83	0.83	1.09
WEK	47	19.78	18.76	20.02	19.55	19.44	21.03	20.76	20.85	20.09	21.15	20.88	20.71	1.25	1.33	1.13	1.33	1.13	1.26
KEB	443	21.84	20.55	22.19	21.25	21.33	23.09	22.90	23.18	21.95	23.45	22.57	22.66	1.25	1.40	1.25	1.32	1.25	1.32
CEU	181	21.43	21.00	21.49	20.40	20.97	22.71	22.77	22.55	22.42	22.73	21.78	22.31	1.28	1.42	1.24	1.38	1.24	1.34
SES	128	21.26	21.18	21.22	20.99	21.13	22.53	22.79	22.33	22.57	22.52	22.29	22.46	1.27	1.39	1.30	1.29	1.29	1.33
YES	330	21.33	20.81	20.89	20.90	20.87	22.52	22.60	22.11	22.47	22.06	22.05	22.20	1.19	1.66	1.17	1.15	1.15	1.33
TEW	402	21.00	20.19	21.05	20.79	20.68	22.29	21.64	22.33	21.53	22.32	22.16	22.00	1.29	1.34	1.27	1.37	1.27	1.32
NEC	24	20.87	20.71	21.07	19.49	20.42	22.11	22.27	21.81	21.98	22.46	20.79	21.74	1.24	1.27	1.38	1.30	1.27	1.32
VEE	63	18.67	18.13	17.77	18.26	18.05	20.00	19.97	20.27	19.94	19.26	20.07	19.76	1.33	1.81	1.49	1.81	1.49	1.70
REE	23	20.65	19.98	20.73	20.48	20.40	21.90	21.59	22.16	21.32	21.99	21.87	21.72	1.25	1.33	1.26	1.39	1.26	1.33
WCV	15	21.24	20.36	21.37	21.41	21.05	22.71	22.44	22.71	21.93	22.67	22.87	22.49	1.47	1.56	1.30	1.46	1.30	1.44
KCM	476	21.87	20.73	22.25	21.15	21.38	23.40	23.75	23.10	22.37	23.74	22.70	22.93	1.53	1.64	1.49	1.55	1.49	1.56
CCL	274	21.24	20.32	20.86	19.74	20.31	22.77	23.01	22.38	22.21	22.28	21.54	22.01	1.53	1.89	1.42	1.80	1.42	1.71
SCT	73	21.42	20.57	21.20	21.07	20.95	23.02	22.49	23.45	22.18	22.74	22.69	22.54	1.60	1.61	1.54	1.62	1.54	1.59
YCB	56	21.24	19.86	21.06	20.66	20.52	22.71	22.36	22.88	21.50	22.62	22.14	22.09	1.47	1.65	1.55	1.49	1.49	1.56
TCA	460	20.76	19.60	20.89	20.28	20.26	22.19	21.59	22.05	21.17	22.26	21.78	21.74	1.43	1.57	1.37	1.50	1.37	1.48
NCV	151	20.66	19.89	21.09	19.54	20.17	22.16	22.05	22.14	21.57	22.51	21.39	21.82	1.50	1.68	1.43	1.85	1.43	1.65
VCE	51	19.47	19.10	19.41	19.02	19.18	21.00	21.09	20.85	20.87	20.79	21.04	20.90	1.53	1.77	1.38	2.02	1.38	1.73
RCK	114	21.10	21.06	20.87	20.14	20.69	22.55	22.60	22.49	22.67	22.52	21.67	22.29	1.45	1.61	1.65	1.53	1.53	1.60
WBA	73	20.33	19.68	20.40	20.51	20.20	22.31	22.16	22.25	21.61	22.46	22.58	22.22	1.98	1.93	2.06	2.07	1.93	2.02
KBW	252	21.15	20.58	21.37	20.57	20.84	23.22	23.26	23.04	22.71	23.58	22.51	22.93	2.07	2.13	2.21	1.93	1.93	2.09
CBS	168	21.52	21.44	21.18	20.61	21.08	23.62	23.51	23.12	23.64	23.33	22.72	23.23	2.10	2.20	2.16	2.11	2.11	2.16
SBZ	238	21.13	19.92	21.13	21.63	20.89	23.10	22.99	23.26	21.91	23.25	23.52	22.89	1.97	1.99	2.13	1.89	1.89	2.00
YBC	346	20.91	20.43	20.51	19.81	20.25	23.00	23.26	22.77	22.69	22.59	22.01	22.43	2.09	2.26	2.09	2.20	2.09	2.18
TBC	547	20.86	19.56	20.66	20.79	20.33	22.96	22.05	23.12	21.62	22.62	22.76	22.33	2.10	2.06	1.96	1.97	1.96	2.00
NBC	60	21.13	20.00	21.05	20.90	20.65	23.10	23.15	22.93	22.12	23.08	22.90	22.70	1.97	2.12	2.04	2.00	2.00	2.05
VBH	21	17.33	15.74	17.07	17.52	16.78	19.34	18.87	19.48	17.79	19.06	19.56	18.80	2.01	2.05	1.99	2.03	1.99	2.02
RBB	169	20.88	19.89	21.02	21.15	20.69	22.86	22.36	22.96	21.96	23.32	23.50	22.93	1.98	2.07	2.30	2.35	2.07	2.24
WAZ	95	20.34	19.76	20.41	20.41	20.19	22.91	22.68	23.04	22.19	22.89	22.77	22.62	2.57	2.43	2.48	2.36	2.36	2.42
KAS	295	20.86	19.50	21.32	20.13	20.32	23.46	23.26	23.48	22.21	23.97	22.46	22.88	2.60	2.71	2.65	2.32	2.32	2.56
CAT	242	21.57	20.14	21.08	21.29	20.83	24.10	23.59	24.17	22.80	23.66	23.80	23.42	2.53	2.66	2.58	2.51	2.51	2.58
SAB	537	21.15	20.96	21.30	20.68	20.98	23.82	23.86	23.67	23.62	24.08	23.15	23.61	2.67	2.66	2.77	2.47	2.47	2.63
YAZ	401	21.71	20.17	21.65	21.41	21.08	24.10	23.95	23.97	22.71	24.14	23.98	23.61	2.39	2.54	2.49	2.57	2.49	2.53
TAA	557	21.10	19.06	20.66	21.65	20.46	23.81	22.82	24.49	21.91	23.55	24.43	23.30	2.71	2.86	2.89	2.78	2.78	2.84
NAW	80	20.53	20.38	21.09	19.47	20.32	23.06	22.88	23.18	22.88	23.71	22.16	22.92	2.53	2.50	2.62	2.69	2.50	2.60
VAB	11	19.09	18.23	19.15	18.63	18.67	21.43	20.74	21.61	20.32	21.56	21.15	21.01	2.34	2.09	2.41	2.52	2.09	2.34
RAS	298	20.72	19.18	20.62	20.89	20.23	23.24	23.01	23.45	21.81	23.11	23.56	22.83	2.52	2.63	2.49	2.67	2.49	2.60
KLK	118	40.69	40.01	41.20	39.04	40.08	43.21	43.50	42.68	42.57	43.75	41.93	42.75	2.52	2.56	2.55	2.90	2.55	2.67
SLH	44	40.30	39.32	40.16	39.54	39.67	43.00	43.17	42.90	41.98	42.90	42.09	42.32	2.70	2.66	2.74	2.55	2.55	2.65
YLL	0	40.38	39.76	39.84	39.48	39.69	43.00	43.64	42.96	42.75	42.62	42.16	42.51	2.62	2.99	2.78	2.68	2.68	2.81
TLH	686	38.19	39.10	37.75	37.33	38.06	40.72	40.82	39.69	41.66	40.53	39.90	40.70	2.53	2.56	2.78	2.57	2.56	2.64
ULH	653	42.52	42.89	41.72	42.75	42.45	44.95	45.09	44.71	45.61	44.27	45.18	45.02	2.43	2.72	2.56	2.43	2.43	2.57
RLE	401	38.70	38.06	38.58	37.73	38.12	41.37	41.06	41.06	41.04	41.30	40.67	41.01	2.67	2.98	2.72	2.95	2.72	2.88

TABLE VI.—LOCATION OF SPECIMENS ON TEST RACKS.

THE GALVANIZED SPECIMENS FROM TOP END OF SHEET ARE ON WEST SIDE OF RACK, FROM BOTTOM END ON EAST SIDE

NORTH

WEST

BRUNOT ISLAND		ALTOONA		STATE COLLEGE		SANDY HOOK		KEY WEST	
UXT*	WLB*	ULT*	WHT*	USB*	WBB*	UBT*	WKB*	UVB*	WAB*
CTT*	KAB*	CLT*	KXT*	CMT*	KNT*	CBT*	KST*	CUT*	KVT*
YHB*	SNB*	YVT*	SXT*	YWT*	SCT*	YZB*	SST*	YZT*	SUT*
TZT*	NBT*	TBT*	NHT*	TNT*	NET*	TVT*	NBB*	TLB*	NKT*
VCB*	RZT*	VBB*	RXT*	VET*	RBB*	VAT*	RZB*	VAB*	RKB*
KKH	KKH	KKC	KKC	KKK	KKK	KKA	KKA	KKB	KKB
SKK	SKK	SKC	SKC	SKA	SKA	SKE	SKE	SKL	SKL
YKK	YKK	YKH	YKH	YKM	YKM	YKC	YKC	YKE	YKE
TKE	TKE	TKA	TKA	TKM	TKM	TKC	TKC	TKL	TKL
NKB	NKB	NKK	NKK	NKH	NKH	NKL	NKL	NKC	NKC
KHT	KHT	KHK	KHK	KHC	KHC	KHS	KHS	KHX	KHX
CHM	CHM	CHN	CHN	CHA	CHA	CHU	CHU	CHT	CHT
SHV	SHV	SHE	SHE	SHC	SHC	SHA	SHA	SHT	SHT
YHS	YHS	YHC	YHC	YHH	YHH	YHM	YHM	YHN	YHN
THA	THA	THK	THK	THS	THS	THN	THN	THH	THH
NHK	NHK	NHH	NHH	NHA	NHA	NHX	NHX	NHB	NHB
VHH	VHH	VHC	VHC	VHE	VHE	VHA	VHA	VHB	VHB
WEM	WEM	WEN	WEN	WET	WET	WEC	WEC	WEK	WEK
KEN	KEN	KEL	KEL	KEW	KEW	KES	KES	KEB	KEB
CET	CET	CEC	CEC	CEL	CEL	CEX	CEX	CEU	CEU
SEA	SEA	SEW	SEW	SEX	SEX	SEV	SEV	SES	SES
YEC	YEC	YEA	YEA	YEX	YEX	YEU	YEU	YES	YES
TEC	TEC	TEN	TEN	TEK	TEK	TEV	TEV	TEW	TEW
NEL	NEL	NES	NES	NEU	NEU	NEV	NEV	NEC	NEC
VEA	VEA	VEB	VEB	VEH	VEH	VEC	VEC	VEE	VEE
REL	REL	REW	REW	RET	RET	REK	REK	REE	REE
WCM	WCM	WCA	WCA	WCK	WCK	WCS	WCS	WCV	WCV
KCX	KCX	KCB	KCB	KCN	KCN	KCS	KCS	KCM	KCM
CCM	CCM	CCB	CCB	CCC	CCC	CCX	CCX	CCL	CCL
SCB	SCB	SCE	SCE	SCL	SCL	SCA	SCA	SCT	SCT
YCN	YCN	YCK	YCK	YCA	YCA	YCL	YCL	YCB	YCB
TCV	TCV	TCL	TCL	TCX	TCX	TCT	TCT	TCA	TCA
NCU	NCU	NCX	NCX	NCA	NCA	NCL	NCL	NCV	NCV
VCH	VCH	VCB	VCB	VCC	VCC	VCA	VCA	VCE	VCE
RCW	RCW	RCX	RCX	RCZ	RCZ	RCL	RCL	RCK	RCK
WBT	WBT	WBS	WBS	WBC	WBC	WBE	WBE	WBA	WBA
KBX	KBX	KBN	KBN	KBT	KBT	KBS	KBS	KBW	KBW
CBH	CBH	CBA	CBA	CBB	CBB	CBZ	CBZ	CBS	CBS
SBV	SBV	SBC	SBC	SBT	SBT	SBX	SBX	SBZ	SBZ
YBB	YBB	YBX	YBX	YBU	YBU	YBV	YBV	YBC	YBC
TBB	TBB	TBW	TBW	TBM	TBM	TBA	TBA	TBC	TBC
NBV	NBV	NBU	NBU	NBT	NBT	NBH	NBH	NBC	NBC
VBE	VBE	VBA	VBA	VBC	VBC	VBB	VBB	VBH	VBH
RBH	RBH	RBE	RBE	RBX	RBX	RBV	RBV	RBB	RBB
WAS	WAS	WAL	WAL	WAE	WAE	WAT	WAT	WAZ	WAZ
KAN	KAN	KAA	KAA	KAM	KAM	KAZ	KAZ	KAS	KAS
CAV	CAV	CAE	CAE	CAH	CAH	CAM	CAM	CAT	CAT
SAM	SAM	SAS	SAS	SAW	SAW	SAL	SAL	SAB	SAB
YAA	YAA	YAT	YAT	YAC	YAC	YAV	YAV	YAZ	YAZ
TAV	TAV	TAH	TAH	TAX	TAX	TAU	TAU	TAA	TAA
NAK	NAK	NAS	NAS	NAT	NAT	NAU	NAU	NAW	NAW
VAE	VAE	VAC	VAC	VAA	VAA	VAH	VAH	VAB	VAB
RAA	RAA	RAT	RAT	RAH	RAH	RAC	RAC	RAS	RAS
KLH	KLH	KLM	KLM	KLE	KLE	KLA	KLA	KLK	KLK
SLA	SLA	SLE	SLE	SLM	SLM	SLB	SLB	SLH	SLH
YLB	YLB	YLC	YLC	YLK	YLK	YLE	YLE	YLL	YLL
TLC	TLC	TLK	TLK	TLM	TLM	TLB	TLB	TLH	TLH
ULC	ULC	ULM	ULM	ULK	ULK	ULB	ULB	ULH	ULH
RLC	RLC			RLA	RLA	RLB	RLB	RLE	RLE

EAST

* Black sheets.

SOUTH

punched as shown in Fig. 6. During the corrugation, no flaking was observed on any of the specimens.

The spot test specimens of standard $2\frac{1}{4}$-in. dimensions were then punched from the left-hand side of the top spot-test strip, from the center of the middle spot-test strip, and from the right side of the bottom spot-test strip. These specimens were properly marked and forwarded to the Bureau of Standards for weight of coating determinations.

Upon receipt of this information, the committee assigned sheets to the test stations and reserve stock. Realizing that some variation occurs in any one class of coating, for instance the $2\frac{1}{2}$-oz. coating, the sheets were chosen for, first, the uniformity of all three spot tests, and second, nearness to the desired coating. Those carrying the heaviest weight of coating of any class were sent to Key West, the next to Brunot Island, the next to Sandy Hook, the next to Altoona, and the lightest to State College. The black sheet specimens were also chosen with respect to nearness to the theoretical weight. The data for the sheets which are erected on the various racks are given in Tables I to V. The reserve stock is to be forwarded to the Bureau of Standards for storage.

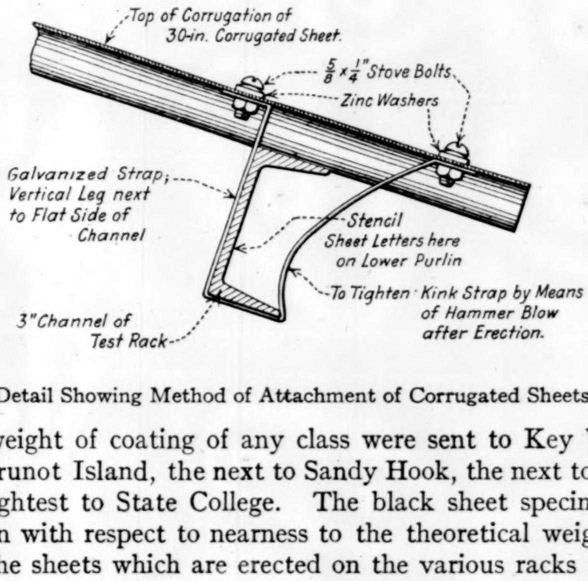

Top of Corrugation of 30-in. Corrugated Sheet.
$\frac{5}{8}\times\frac{1}{4}$" Stove Bolts
Zinc Washers
Galvanized Strap; Vertical Leg next to Flat Side of Channel
Stencil Sheet Letters here on Lower Purlin
To Tighten Kink Strap by Means of Hammer Blow after Erection.
3" Channel of Test Rack

FIG. 7.—Detail Showing Method of Attachment of Corrugated Sheets to Rack.

The corrugated specimens forwarded to the northern racks were carefully packed and sealed in tar paper. The specimens forwarded to Key West were packed in soldered tin-lined cases, while the reserve stock is packed in soldered tin-lined cases.

Erection:

The committee placed the sheets on the rack, the locations being indicated in Table VI. The corrugated specimens from the top half of the sheets were erected with the bottom surface upward on the west side of the rack. The corrugated specimens from the bottom half of the sheets were erected with the top surface upward on the east side of the rack, the corrugations being erected perpendicular to the ridge of the rack. The sheets were attached to the purlins by means of hot-dip galvanized straps, $\frac{1}{4}$-in. hot-dip galvanized stove bolts and zinc washers as indicated in Fig. 7. The stove bolts were furnished by the Diamond Expansion Bolt Co., the zinc washers and straps, by The New Jersey Zinc Co. Eight bolts and four straps were used for each specimen and after being attached the strap was kinked to prevent undue rattling. The designating letters were stenciled under each specimen on the inside face of the lower purlin on both sides of the rack. The black sheets were placed on the northern-most end of the rack, as indicated in Table VI, and were attached with galvanized straps, bolts and zinc washers, similarly to the galvanized sheets.

The sheet specimens at Brunot Island were exposed April 21, 1926, at Altoona, April 22, 1926, at State College, April 23, 1926, at Sandy Hook, May 20, 1926, and at Key West, June 11, 1926. Figures 13 to 17 show the racks with the sheet specimens thereon (except in one instance).

BEND SPECIMENS

Strips, 9 in. wide, cut from the sheets erected on the five test locations, were forwarded to The New Jersey Zinc Co., at Palmerton, Pa., where the No. 22 and No. 28-gage samples were formed into the specimens for the rack. The No. 16-gage samples were formed at the Wellsville Works of The American Sheet and Tin Plate Co.

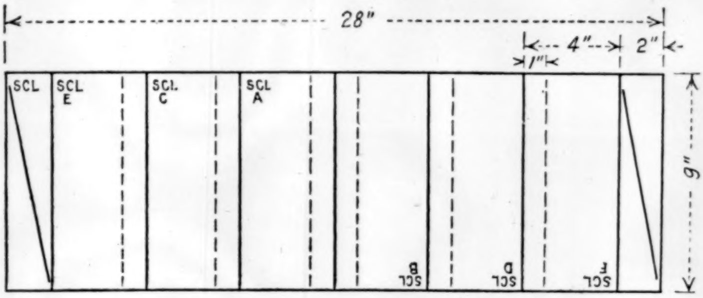
The sub-committee decided that the bend specimens were to be formed over mandrels of graduated thicknesses, this thickness being expressed in multiples of the nominal thickness of the specimens. It was realized that light gages were best able to withstand the severest forming; therefore the following mandrels were designated to be used for the specimens of the corresponding gages:

GAGE	SPECIFIED BEND[a]
No. 22	Over mandrels Nos. 1, 3, 4, 6, 8 and 12
No. 28	On itself, and over mandrels Nos. 1, 2, 3, 4 and 6
No. 16	Over mandrels Nos. 2, 4, 6, 8, 10 and 12

---

[a] Mandrel numbers signify thickness of mandrel in terms of thickness of specimen.

The strips were marked with the code letter so located that when held with the letters right-side up, the first edge of the strip through the bath was at the top, the lettered side being the top of the sheet as it passed through the galvanizing pot. Strips 2 in. wide from each end of the strip (the edges of the original sheet) were discarded, which left sufficient stock for six 4 by 9-in. specimens. These specimens were cut from the strip as shown in Fig. 8 and were marked with the sheet code letter and the mandrel number over which they were bent, in the position shown. These mandrel numbers signified the thickness of the mandrel in terms of the thickness of the specimens. These specimens were next punched with two $\frac{5}{16}$-in. holes, near the marked edge, and then bent.



Dotted Lines show Position of Bend.
Where Lower Letter A, B, C, D, E and F is shown on Sketch, use Number shown in the following Table according to Gage of Sheet.

MANDREL MARK.

Sheet Code Letter.	22 Gage.	28 Gage.	16 Gage.
A	1	0	2
B	3	1	4
C	4	2	6
D	6	3	8
E	8	4	10
F	12	6	12

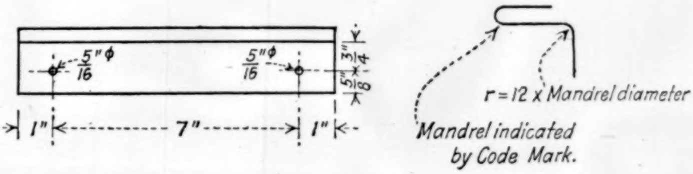
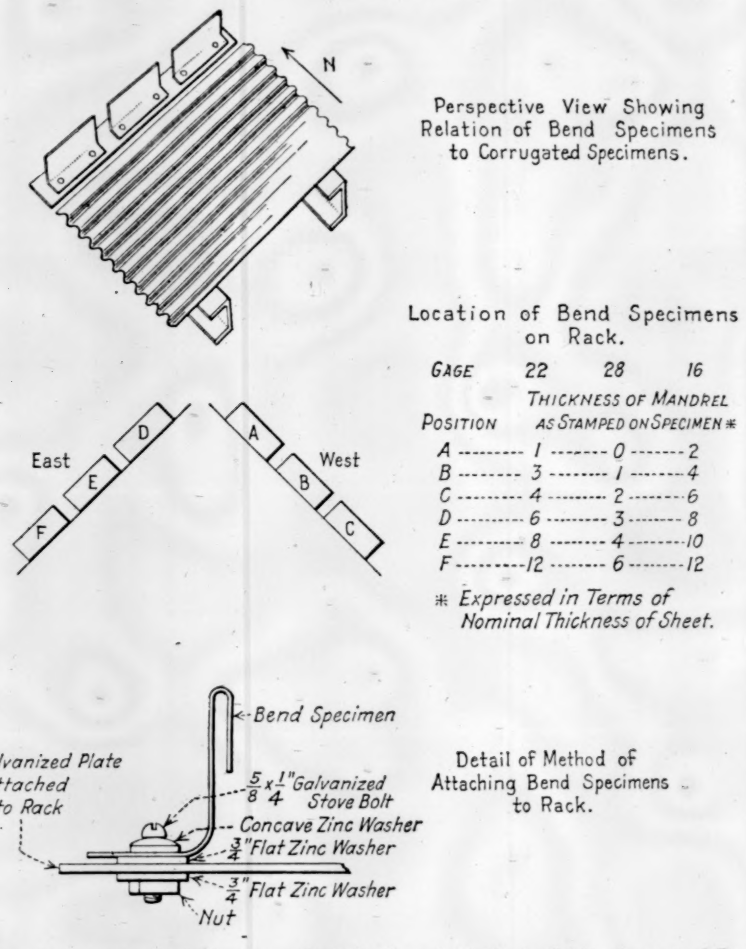


FIG. 8.—Fabrication of Bend Specimens.

Steel mandrels of the proper thickness were made, the edge of the mandrel over which the specimen was bent being rounded with a diameter equal to that of the mandrel.

The bending was performed in a regular tin-smith's brake. The mandrels and the specimens were inserted in the jaws and the specimens bent through approximately 150 deg. The specimens were then reversed in the brake and flattened down over the mandrels to the shape illustrated. The thicknesses over which the bend specimens were bent for the various gages of stock are given in Fig. 8.


N
East
West
A
B
C
D
E
F
Bend Specimen
Galvanized Plate Attached to Rack
$\frac{5}{8}$x$\frac{1}{4}$" Galvanized Stove Bolt
Concave Zinc Washer
$\frac{3}{4}$" Flat Zinc Washer
$\frac{3}{4}$" Flat Zinc Washer
Nut

Perspective View Showing Relation of Bend Specimens to Corrugated Specimens.

Location of Bend Specimens on Rack.

GAGE	22	28	16
POSITION	THICKNESS OF MANDREL AS STAMPED ON SPECIMEN *		
A	1	0	2
B	3	1	4
C	4	2	6
D	6	3	8
E	8	4	10
F	12	6	12

* Expressed in Terms of Nominal Thickness of Sheet.

Detail of Method of Attaching Bend Specimens to Rack.

FIG. 9.—Arrangement of Sheets on Test Rack and Method of Attachment of Bend Specimens.

An inspection was made as to the flaking of the specimens after bending, which will be subsequently reported upon, after which the bend specimens corresponding to specimens erected on the various racks were shipped to the test locations.

Erection:

These bend specimens were erected on the flat strip provided on the sheet test rack as illustrated in Fig. 9. The bend specimens corresponding to each sheet were located on the northerly side of the sheet and in the order illustrated in Fig. 9. They were attached by means of galvanized stove bolts and solid zinc washers as illustrated.

The bend specimens on the Brunot Island rack were erected April 21, 1926; on the Altoona rack, April 22, 1926; on the State College rack, April 23, 1926; on the Sandy Hook rack, May 20, 1926; and on the Key West rack, November 8, 1926.

INSPECTION OF GALVANIZED SHEETS AND BEND SPECIMENS

A meeting of the Sheet Inspection Committee of the sub-committee, M. E. McDonnell, chairman, and other interested members, was held at Palmerton, Pa., on November 22, 1926, at which time a general plan was adopted. At this meeting, W. H. Finkeldey exhibited galvanized sheets that had been exposed to atmospheric action over varying periods of time, and called attention to the progress of failure, the initial coating of zinc ultimately disappearing and exposing the alloy layer. Further exposure results in the development of yellowish corrosion products of the alloy layer, followed by the red oxide corrosion of the base metal, and finally complete corrosion through the base. It was unanimously agreed that the successive conditions of the galvanized specimens during the course of exposure, terminating in destruction, would be classified as follows:

Case Z.—Continuous zinc surface, together with attendant corrosion products of zinc;

Case A.—Zinc-iron alloy layer visible;

Case Y.—Yellowish discoloration, due to the mixed corrosion products of zinc and iron;

Case R.—Exposure of base, where the original coating no longer exists, as indicated by a rough, reddish corrosion product;

Case H.—First perforation of the sheet by corrosion.

In reporting the conditions as found at the periods of inspection, abnormal results found at the edges of the coating will be disregarded, the margin being 1 in. wide. Also failures due to mechanical injury, and obvious stains of external origin will not be considered in making classifications. Rust spots less than $\frac{1}{8}$ in. in diameter will not change the classification of a failure to the ones designated *Y* or *R*. For Case *H*, an additional inspection report shall be made to include the edges.

A committee, under the chairmanship of C. S. Trewin, was appointed to collect a triplicate series of galvanized sheets illustrating the successive stages of corrosion. These have been assembled, and one set designated "Standard" has been deposited with a custodian, C. D. Hocker of the Bell Telephone Laboratories, Inc., for preservation in a dry, fire-proof vault. One set, marked "Portable No. 1," is retained by the chairman of Sub-Committee VIII to be photographed for the records of the Society. The third set, marked "Portable No. 2," is retained by the chairman of the Sub-Committee on Sheet Inspection, to be used at all official inspections of the sheets undergoing test, as a guide to inspection in making classifications. A standard set of classification sheets contains the following illustrations:

Z.—Predominantly metallic zinc.

A1.—Predominantly dark gray or black alloy layer.

A2.—Largest amount black alloy layer.

Y1.—Least amount yellowed alloy layer.

Y2.—Predominantly yellowed alloy layer.

Y3.—Largest amount yellowed alloy layer.

RSD.—Representing a rust spot $\frac{1}{8}$ in. in diameter.

R1.—Rust spot regardless predominant appearance of the sheet as a whole.

R2.—Small amount of rusting.

R3.—Predominantly rusting.

R4.—Complete rusting or disappearance of the coating.

In grading sheets at inspection periods, if the area of the exposed alloy layer does not exceed 50 per cent of the total area, the sheet shall be rated class *Z*. However, small exposed areas of the alloy layer are to be recorded on the record diagram described later.

Sheets showing a predominating area of yellowed condition due to oxidation of the zinc-iron alloy layer will be rated *Y*. Smaller yellow zones will not be sufficient cause for rating a panel *Y*, but such spots will be recorded in the record diagrams.

Any sheet showing a rust spot exceeding $\frac{1}{8}$ in. in diameter shall be rated *R*, regardless of the predominant appearance of the sheet as a whole.

When a hole is found in any sheet it will be classified by the designation *H*. Sheets so classified will not receive further attention at inspection periods, and it may be considered that they have failed.

The grading and classification of bend test specimens is more complicated, due to the effect of flaking of the zinc coating which may result from the bending operation. It is proposed to use the classification *H*, as for sheets, if a hole develops at the bend. This classification will also apply if the bend test specimen breaks into two pieces at the bend. a condition which is likely to result when the base metal has been cracked by the bending operation and subsequent exposure to varying wind pressures. The Inspection Committee is now endeavoring to devise a method of measuring the degree of rusting at bends, and to correlate this with the flaking noted at the time the bends were made.

For the purpose of describing the location of any of the above conditions of corrosion on sheets, E. S. Taylerson proposed the use of a system of coordinate lines by means of a superimposed templet. This proposal was accepted by the committee, and templets have been prepared for the use of inspectors. These templets, which fit the standard sheets, have a frame 1 in. wide to exclude the edges to be disregarded. Strings to represent coordinate lines are stretched at intervals of 5 in., for the purpose of locating definite spots. The distances of points between these 5-in. lines are estimated. The lines on the templet are numbered 5, 10, 15, etc., from the upper left-hand corner. In reading and recording locations, the abscissa figures shown on the upper margin of the templet are followed by the ordinate figures indicated on the left margin. Fig. 10 illustrates the use of this templet during the inspection of a sheet.

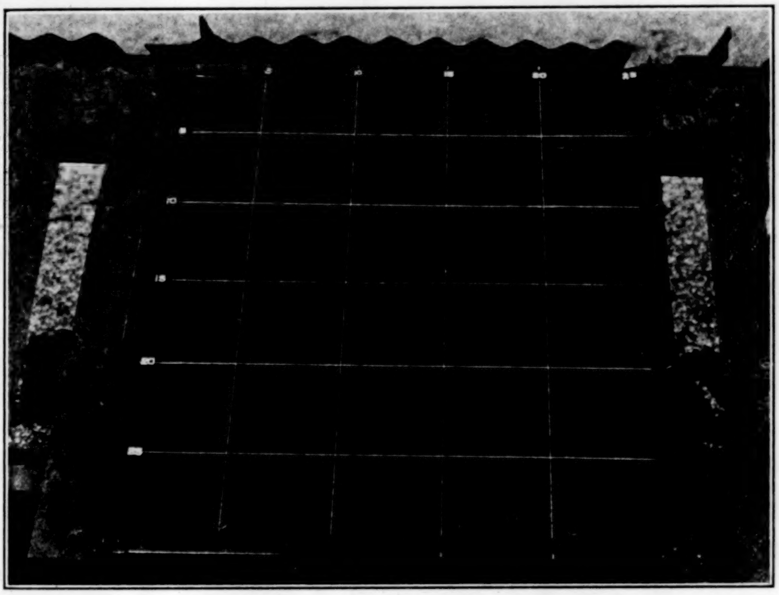
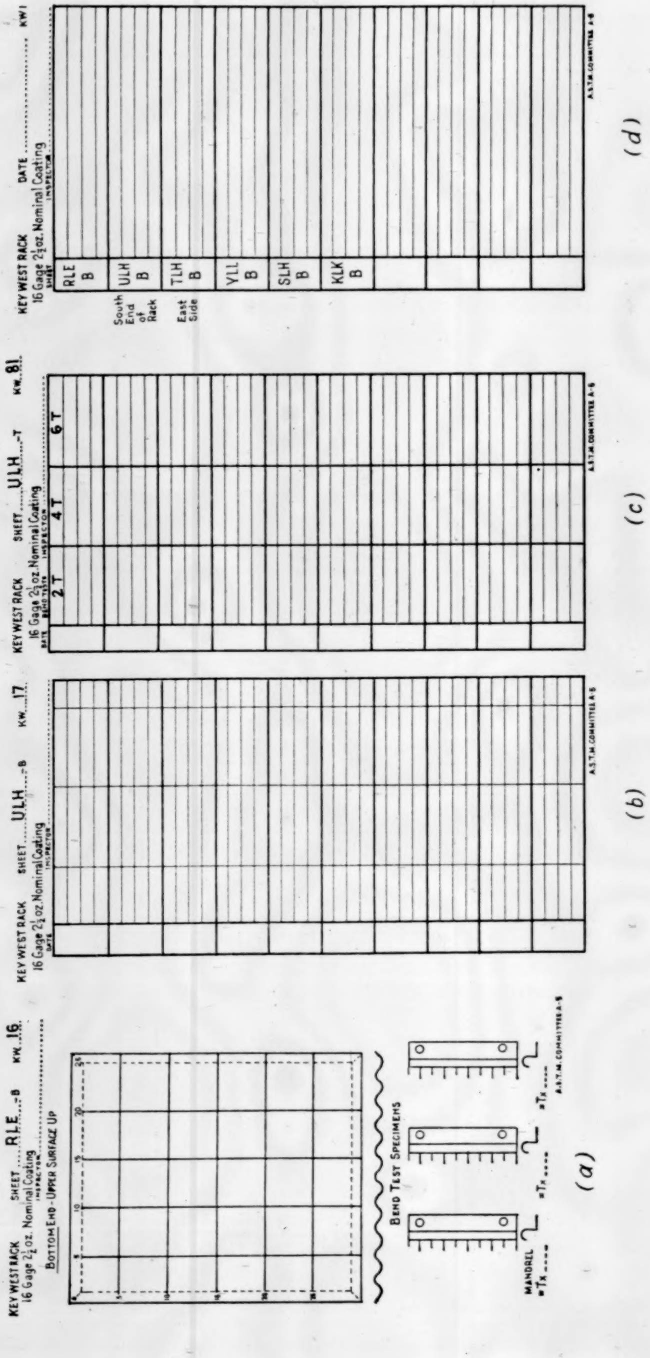


FIG. 10.—Templet for Use in Inspecting Sheets.


KEY WEST RACK SHEET RLE-B KW 16
16 Gage 2½ oz. Nominal Coating INSPECTOR
BOTTOM END - UPPER SURFACE UP
BEND TEST SPECIMENS
MANDREL =Tx
=Tx
=Tx
=Tx
A.S.T.M. COMMITTEE A-5
KEY WEST RACK SHEET ULH-B KW 17
16 Gage 2½ oz. Nominal Coating INSPECTOR
DATE
A.S.T.M. COMMITTEE A-5
KEY WEST RACK SHEET ULH-T KW 81
16 Gage 2½ oz. Nominal Coating INSPECTOR
DATE BEND TESTS
2 T
4 T
6 T
A.S.T.M. COMMITTEE A-5
KEY WEST RACK DATE KW 1
16 Gage 2½ oz. Nominal Coating INSPECTOR
SHEET
RLE B
ULH B
TLH B
YLL B
SLH B
KLK B
South End of Rack
East Side
A.S.T.M. COMMITTEE A-5

(a) (b) (c) (d)

FIG. 11—Loose Leaf Inspection Forms for Recording Inspections of Sheets.

PLATE V.
PROC. AM. SOC. TESTING MATS.
VOL. 27, PART I.
REPORT OF COMMITTEE A-5:
FIELD TESTS OF METALLIC COATINGS.

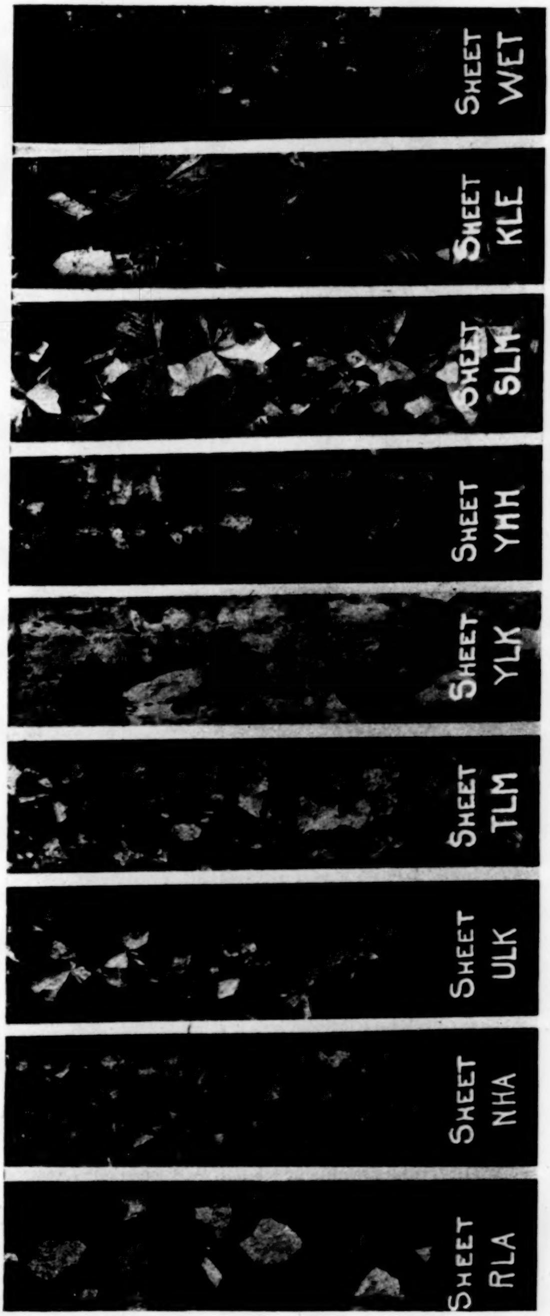

SHEET RLA
SHEET NHA
SHEET ULK
SHEET TLM
SHEET YLK
SHEET YMH
SHEET SLM
SHEET KLE
SHEET WET

FIG. 12.—Illustrating Types of Spangle on Sheets.

A small committee, under the chairmanship of H. E. Smith, prepared plans for forms for inspection records. These include a 1-page ruled chart for sketches of each sheet and the three accompanying bend specimens, as illustrated by Fig. 11(*a*). These charts are used for making sketches of conditions to be described, and colored pencils may be used to indicate classes (yellow and red). Permanent records for notes to be made at successive inspections were prepared for each sheet and corresponding bend specimens on test. These are illustrated by Figs. 11(*b*) and (*c*). A work form applying to single inspection periods, as shown in Fig. 11(*d*), was also prepared. These forms were printed and inserted in loose-leaf binders, each inspector carrying a full set of forms for each test rack.

The committee has made one inspection of the tests now on exposure on the test racks at the five locations selected.

The tests at Key West, Fla., were examined on January 15, 1927. At that time the corrugated sheets had been out 220 days and the bend tests 107 days. Those present were Messrs. F. A. Hull, E. S. Taylerson, F. A. Weidman (representing Mr. W. C. Carroll) and M. E. McDonnell.

The tests at Sandy Hook were examined on March 19, 1927. At that time the corrugated sheets had been out 303 days and the bend tests 99 days. Those present were Messrs. R. L. Duff, C. D. Hocker, R. D. Brooks (representing Mr. W. J. Beck), G. A. Reinhardt, E. S. Taylerson, C. S. Trewin, and M. E. McDonnell, also visitors W. H. Finkeldey, C. A. Giblin, H. W. Pleister and F. A. Weidman.

The tests at Brunot Island, Pittsburgh, were examined on April 6, 1927, at which time the corrugated sheets had been out 350 days and the bend test specimens 117 days. Those present were Messrs. J. H. Gibboney, R. L. Duff, C. D. Hocker, W. C. Carroll, R. M. Curts (representing Mr. C. S. Trewin), R. F. Passano (representing Mr. W. J. Beck), H. S. Rawdon, G. A. Reinhardt, H. E. Smith, E. S. Taylerson, and M. E. McDonnell. Messrs. Max Hecht and F. A. Weidman were present as visitors at this inspection.

The above named members of the Inspection Committee, excepting Mr. Carroll, who was represented by Mr. F. A. Weidman, inspected the tests at Altoona on April 7. The corrugated sheets at this point had been out 350 days and the bend tests 167 days. The Altoona group of inspectors was joined by a visitor, Mr. C. A. Giblin, at State College, on April 8, and the tests at this location were inspected. These corrugated sheets had been exposed 350 days and the bend test specimens 164 days.

The inspections revealed the fact that the coating on all corrugated sheets was still within the classification designated *Z*. A certain amount of zinc alloy layer, described as "chatter marks," was observed on some sheets, but even in these instances the predominating coating was zinc. No rust spots were observed on any sheet. Those located at Brunot Island and Altoona showed a carbon deposit from smoke, which obscured structural detail, but this condition did not prevail at the other three locations. The crystallin appearance of the coating varied from that of large spangles to that of a dull gray alloy. Figure 12 (Plate V) illustrates the variations in appearance of the coating of nine corrugated sheets exposed at State College and it is to be noted that one of these, Sheet YHH, shows the "chatter marks." It

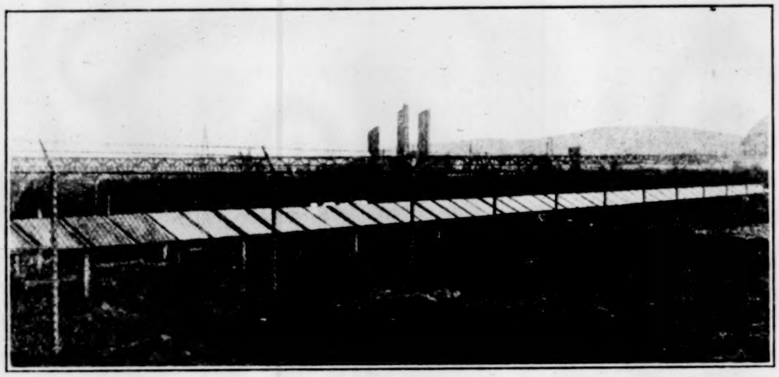


FIG. 13.—Brunot Island (Pittsburgh) Test Rack. Sheets Exposed April 21, 1926. Sheets Photographed April 21, 1926.

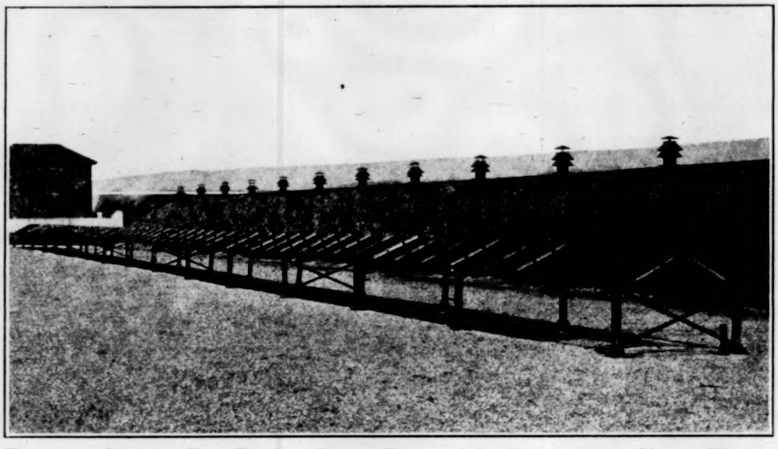


FIG. 14.—Altoona Test Rack. Sheets Exposed April 22, 1926. Sheets Photographed April 7, 1927.

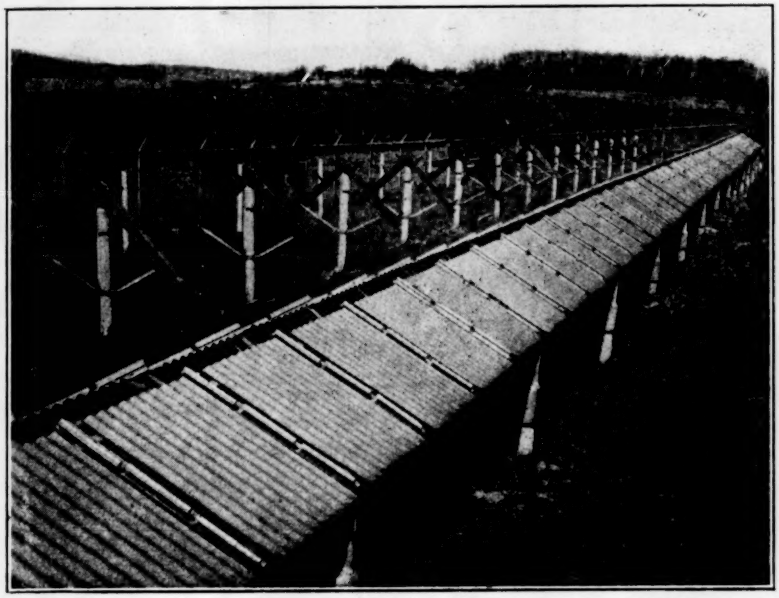


FIG. 15.—Pennsylvania State College Test Rack. Sheets Exposed April 23, 1926. Sheets Photographed April 11, 1927.

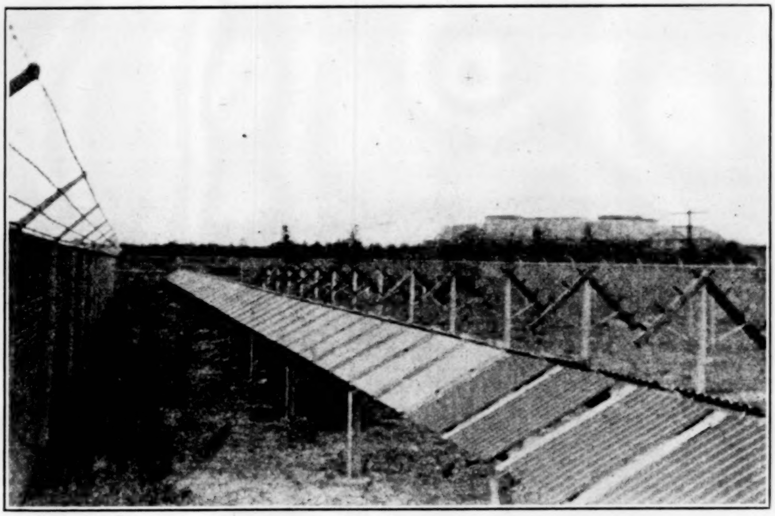


FIG. 16.—Sandy Hook Test Rack. Sheets Exposed May 20, 1926. Sheets Photographed March 19, 1927.

was observed that some of the wrought-iron base metal sheets show longitudinal cracks in the base, and one of these is illustrated by sheet designated *WET* in Fig. 12. Careful notes and diagrams of all observed spots, scratches or other injuries were recorded for reference at inspections to be held in the future. Figures 13 to 17 illustrate the test racks at the five locations.

The bend specimens at all locations were carefully inspected, and observed conditions recorded. One of the first conditions observed was that the transversely bent galvanized wrought-iron base metal specimens develop longitudinal cracks, permitting progressive formation of rust. As a result of this cracked condition, most of the small-radius transversely bent specimens designated 1*T* have now broken off at the bends.

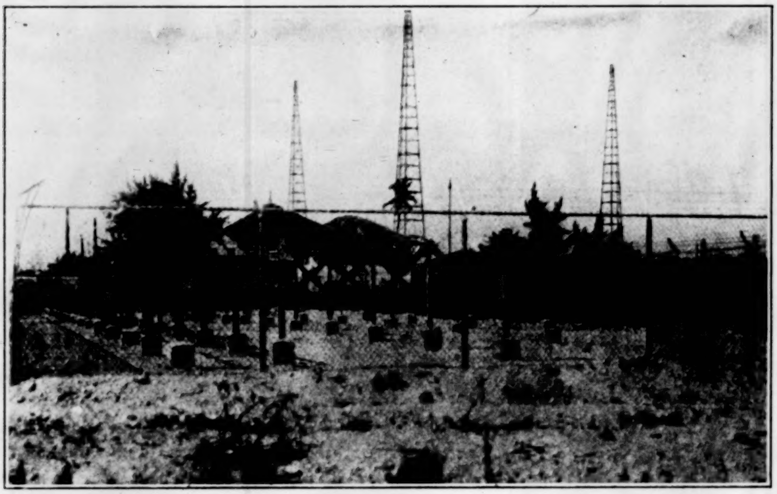


FIG. 17.—Key West Test Rack, Without Sheets. Sheets Exposed May 20, 1926.

Another observation was that in the case of badly flaked bend specimens, rusting of the base metal is occuring at all five test locations. Sufficient data are not yet available for any specific conclusions other than the generally accepted one that, other conditions being the same, flaking is more pronounced as the weight of coating increases.

As a matter of record, photographs of all $2\frac{1}{2}$-oz. coated bend specimens at Altoona, and all $2\frac{1}{2}$-oz. coated No. 16 gage specimens at State College were taken. Figure 18 (Plate VI) illustrates the condition of the bend specimens at the State College location after an exposure of 164 days. At the present time pictures of bend tests at these two locations may be considered generally representative of all five.

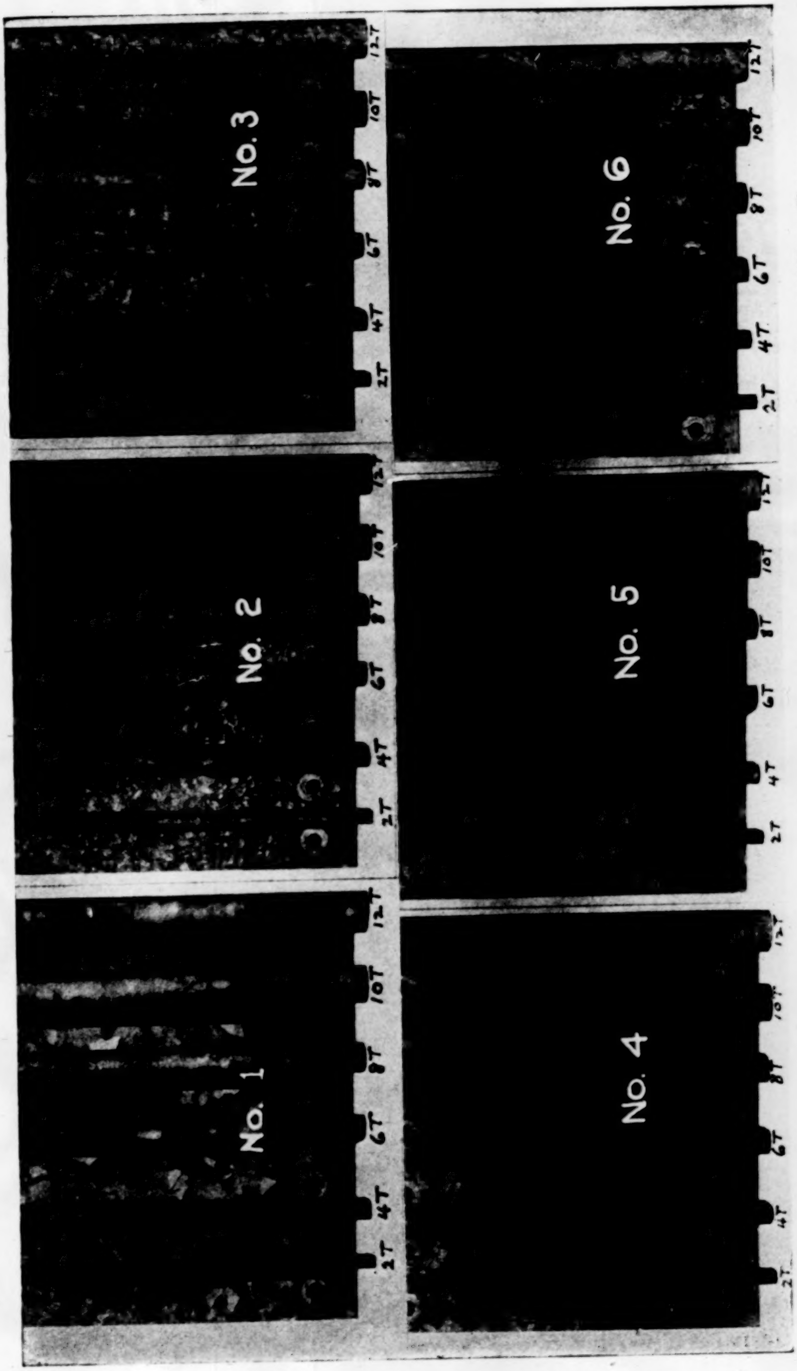

No. 3
No. 2
No. 1
No. 6
No. 5
No. 4
2T
4T
6T
8T
10T
12T

FIG. 18.—Pennsylvania State College Bend Specimens. No. 16 gage, 2½-oz. Nominal Coating, 164 Days Exposure.

The photographs of Altoona tests show that the details resulting from flaking have been somewhat obscured by the deposit of carbon from smoke. For this reason the State College pictures show better detail.

Due to the relatively short time the tests have been exposed, this report must be considered one of progress.

The inspection report has been unanimously approved by the group in charge of this work.

Respectfully submitted on behalf of the sub-committee,

F. A. HULL,
Chairman.

REPORT OF SECTIONAL COMMITTEE
ON
SPECIFICATIONS FOR ZINC COATING OF IRON AND STEEL

The Sectional Committee was formally organized March 16, 1926, under the sponsorship of the American Society for Testing Materials and is functioning under the procedure of the American Engineering Standards Committee. The first meeting of its Executive Committee was held June 11, 1926, and at this meeting seven technical committees were authorized. Shortly thereafter Technical Committees I, II, III, IV, V and VII were organized. Technical Committee VI on Marine Hardware and Ship Fittings, also duly authorized, has not been organized because of lack of interest on the part of the users of those products.

Technical Committee I on Hardware and Fastenings, R. F. Hosford, chairman.—This committee divided its work among three sub-committees, charged as follows:

Sub-Committee A: Products of cast iron, malleable iron and cast steel.

Sub-Committee B: Products of rolled, pressed and forged steel and nails.

Sub-Committee C: Screw-threaded products and rivets.

At a joint meeting of these three sub-committees in October, 1926, it was decided, in view of varied conditions affecting different classes of products and of insufficient information respecting zinc coating weights actually being obtained in commercial practice, to set up and make a detailed study of the several classes of coatings individually applicable to hardware and fastenings, including the gathering of accurate data on zinc coating weights actually being applied in commercial practice. The securing of such data to support definite specifications is being advanced; at the same time the committee is working closely with Technical Committee VII on Methods of Testing.

Technical Committee II on Sheets and Sheet Products, J. T. Hay, chairman.—A sub-committee of this committee held a meeting on May 12, 1927, to draft and submit a report covering certain A.S.T.M.

specifications in this field. In due course, it will report to Technical Committee II, which is working in close cooperation with Committee A-5 on Corrosion of Iron and Steel of the A.S.T.M.

Technical Committee III on Plates, Bars, Structural Shapes and Their Products, V. F. Hammel, chairman.—Following a laboratory test of a set of specimens and coupons, it was agreed that coupons could not be used to determine the weight of zinc coatings; a further opinion expressed by this committee was that at least two ounces per square foot of surface could be expected on material coated in first-class shops.

This committee has asked Technical Committee VII for suggestions in determining the weight of coating on structural material.

Reports of two sub-committees on (1) the question of impurities to be permitted in the zinc bath and (2) the question of bending or forming structural steel materials after galvanizing, have been received and approved by this committee.

When this committee was practically ready to report specifications, it was found necessary to heed the protests of several galvanizers respecting weights of coatings and to enter upon a re-investigation of adequate weights. Before making a definite report, therefore, it will be necessary to hold another meeting of this committee to consider the results of this re-investigation and to make such revision of the specifications as may be deemed desirable.

Technical Committee IV on Pipes, Conduits and Their Fittings, F. N. Speller, chairman.—A preliminary draft of specifications for zinc-coated pipe and fittings is now ready for consideration in detail by the members of this committee's three sub-committees. The final determinations of this committee depend somewhat on the results of the work of the other technical committees.

This committee's physical tests for hot zinc coatings for Class I pipe and fittings will probably be those which are being worked out by a sub-committee of Committee A-5 of the A.S.T.M.

Technical Committee V on Wire and Wire Products, J. C. Johnson, chairman.—This committee has four sub-committees at work. Sub-Committee A: Tentative specifications for telegraph, telephone and signal wire are to be drafted as soon as the comments on corresponding A.S.T.M. specifications are available.

Sub-Committee B: A draft of specifications for stranded wire is now in course of preparation and will be submitted to the sub-committee at an early date.

Sub-Committee C, Fencing and Woven Wire Products: Awaiting report from the Fence Institute on proposed wire fence specifications;

as soon as the Institute is heard from, the sub-committee will be in position to submit a specification. These specifications are the proposed tentative specifications of Committee A-5 of the A.S.T.M.

Sub-Committee D, Wire, Not Otherwise Classified: The subcommittee is attempting to arrive at a basis on which to work.

Technical Committee VII on Methods of Testing, C. D. Hocker, chairman.—Through discussions and answers to a questionnaire, the committee has determined upon the sub-divisions of its work and also that much of the work must be largely investigational for some time.

Sub-committees are operating under the following headings:

Sub-Committee A: Physical Tests of Coatings.
Sub-Committee B: Quantitative Analyses of Coatings.
Sub-Committee C: Other Characteristics of Coating.
Sub-Committee D: Provision of Test Specimens.

On October 28, 1926, the entire personnel of Technical Committee VII was organized as Sub-committee VII on Methods of Testing of Committee A-5 of the A.S.T.M., thus establishing a most desirable correlation between two bodies with similar aims and, more or less, similar personnel.

Respectfully submitted on behalf of the committee,

J. A. CAPP,
Chairman.

S. S. TUTHILL,
Secretary.

REPORT OF COMMITTEE A-6

ON

MAGNETIC PROPERTIES

Committee A-6 has held one meeting during the year in addition to several sub-committee meetings.

The committee recommends the following revisions of the Tentative Methods of Test for Magnetic Properties of Iron and Steel (A 34 - 26 T):[1]

Section 8.—Add a note to Paragraph (*b*) to read as follows:

"NOTE.—If the loss corresponding to a higher induction is desired, the sample should be subjected to a harmonically varying induction having a maximum of 14,000 gausses. The corresponding symbol will be $W_{14/60}$."

Section 9.—Add a note to the tabulation in Paragraph (*d*) to read as follows:

"NOTE.—For the 14,000-gauss test the voltages will be as follows:

$$E = \begin{cases} \text{149.2 volts for high-resistance steel for sine voltage.} \\ \text{145.2 volts for low-resistance steel for sine voltage."} \end{cases}$$

The committee recommends that the tentative methods, as revised, be advanced to standard to supersede the present Standard Methods of Test for Magnetic Properties of Iron and Steel (A34 - 24).[2]

A new sub-committee, Sub-Committee III, has been organized under the chairmanship of Mr. F. P. Fahy, to develop specifications for tests at high magnetizing forces.

Sub-Committee I on Nomenclature and Definitions, W. J. Shackelton, chairman, is submitting as information a proposed set of magnetic terms and definitions, as covered in the appended report of the sub-committee.

Sub-Committee II on Tests at Low Inductions and High Frequencies, R. L. Sanford, chairman, has considered the question of tests of magnetic materials to be used in apparatus operating at high frequencies (audio frequencies) and low inductions such as core materials for audio-frequency transformers, chokes, etc., and submits the appended[3] Test for Magnetic Properties of Iron and Steel at

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 26, Part I, p. 675 (1926); also 1926 Book of A.S.T.M. Tentative Standards, p. 118.

[2] 1924 Book of A.S.T.M. Standards.

[3] See p. 698.—ED.

Low Inductions for Audio and Power Frequencies, which Committee A-6 recommends be accepted for publication as tentative.

The recommendations of the committee appearing in this report have been submitted to letter ballot, with the following results:

Items	Affirmative	Negative	Not Voting
1. Advancement to standard of Tentative Methods of Test for Magnetic Properties of Iron and Steel (A 34 – 26 T), as revised	10	0	2
2. Submission of Tentative Methods of Test for Magnetic Properties of Iron and Steel at Low Inductions for Audio and Power Frequencies	10	0	2

This report has been submitted to letter ballot of the committee, which consists of 12 members, of whom 10 have voted affirmatively, none negatively, and 2 have refrained from voting.

Respectfully submitted on behalf of the committee,

THOMAS SPOONER,
Chairman.

R. L. SANFORD,
Secretary.

EDITORIAL NOTE

The Tentative Methods of Test for Magnetic Properties of Iron and Steel, revised as recommended by the committee, were approved at the annual meeting, to supersede the present Standard Methods of Test for Magnetic Properties of Iron and Steel, and were subsequently adopted by letter ballot of the Society on September 1, 1927. The methods appear in the 1927 Book of A.S.T.M. Standards, Part I.

The proposed Tentative Method of Test for Magnetic Properties of Iron and Steel at Low Inductions for Audio and Power Frequencies were accepted for publication as tentative and appear on page 698.

REPORT OF SUB-COMMITTEE I ON NOMENCLATURE AND DEFINITIONS

Sub-Committee I has been reorganized during the year and now has the following membership:

W. J. SHACKELTON, *chairman.*
F. P. FAHY.
R. L. SANFORD.
W. J. WOOLDRIDGE.

In planning the scope of its initial activities, the sub-committee has reviewed the existing literature on the subject of magnetic tests and materials and has concluded that its first action should be directed towards standardization of terms for those magnetic conceptions and quantities most commonly required in the electrical industry, of definitions for these terms and of symbols for the quantities wherever such are useful. Consideration has been given by the sub-committee to the appended list of such terms, which is offered as information. After approval by the main committee, it is planned to refer the list to Committee E-8 on Nomenclature and Definitions with the suggestion that cooperation with the American Institute of Electrical Engineers be sought with the object of obtaining general adoption of mutually satisfactory standard terms and definitions.

The committee will be glad to receive comments on these proposed definitions.

Respectfully submitted on behalf of the sub-committee,

W. J. SHACKELTON,
Chairman.

APPENDIX

PROPOSED STANDARDIZATION OF MAGNETIC TERMS, UNITS AND SYMBOLS

In the following list of definitions the term defined is given first followed in parenthesis by any optional alternative terms which may be used when the context clearly indicates the intended conception. The symbol for the quantity is then given wherever such symbol is in use, followed by the definition of the standard term.

The name of the unit employed is included, together with the definition of the unit.

BASIC CONCEPTIONS

Magnetic Field (Field).—A portion of space in which the magnetic state is appreciable.

Unit: Not required.

Magnetic Flux (Flux), ϕ.—The magnetic vector which by its variation is capable of producing in an associated electric circuit an electromotive force proportional to its time rate of variation.

Unit: Maxwell.—A magnetic flux of such value that a variation at the rate of one maxwell per second induces one c.g.s. unit of electromotive force in a single electric circuit enclosing the flux.

Magnetic Force (Magnetizing Force, Field Intensity), H.—The magnetic vector which is completely determined by the electric currents present in the field. If the field contains permanent or induced magnets, their equivalent currents may be substituted in determining the magnetic force.

Unit: Gilbert per centimeter.—The magnetic force at the center of a circle of one centimeter radius due to $\frac{1}{2\pi}$ c.g.s. units of current flowing in the circumference of the circle.

DERIVED CONCEPTIONS

Magnetomotive Force, $\mathfrak{F}$.—The integral of the magnetic forces along any line between two points.

Unit: Gilbert.—Unit magnetic force between two points one centimeter apart.

Induction (Flux Density), B.—The flux per square centimeter of any area normal to the direction of the induction.

Unit: Gauss.—One Maxwell per square centimeter.

Normal Induction, B.—The induction in a magnetic material corresponding to a given magnetic force when the material is in a symmetrically cyclic magnetic condition with respect to the given magnetic force.

Unit: Same as for Induction.

Intrinsic Induction (Ferric Induction), B_i.—The excess of the normal induction over that corresponding to the same magnetic force in empty space.

Unit: Same as for Induction.

Saturation Induction, B_s.—The maximum intrinsic induction possible in any material.

Unit: Same as for Induction.

Permeability, μ.—When used without a qualifying adjective, understood to be the *Normal Permeability* as defined below.

Unit: Not required.

Normal Permeability, μ.—The ratio of the normal induction to the corresponding magnetic force.

Unit: Not required.

Initial Permeability, μ_o.—The normal permeability when both the magnetic force and the induction are vanishingly small.

Unit: Not required.

Differential Permeability, μ_d.—The ratio of the positive increase of normal induction to the positive increase of magnetic force when these increases are vanishingly small.

Unit: Not required.

Incremental Permeability, μ_Δ.—The ratio of the cyclic change in induction to the corresponding cyclic change in magnetic force, when the mean induction differs from zero.

Unit: Not required.

Reversible Permeability, μ_r.—The incremental permeability when the change in induction is vanishingly small.

Unit: Not required.

Permeance, $\mathcal{P}$.—The property of any part of a magnetic circuit which determines the flux corresponding to a given magnetic force.

NOTE.—Permeance $= \dfrac{\mu A}{l}$.

where μ = permeability;
A = area in square centimeters; and
l = length in centimeters.

Unit: Not required.

Reluctance, $\mathcal{R}$.—The reciprocal of permeance, $\mathcal{R} = \dfrac{l}{\mu A}$.

Unit: Not required.

Reluctivity, v.—The reluctance between opposite faces of a unit cube of a material.

Unit: Not required.

Residual Induction (Remanence), B_r.—The magnetic induction which remains in a material after the removal of an applied magnetic force.

NOTE.—When the initial induction corresponding to the applied magnetic force is the *normal* induction, the residual induction is called the *normal* residual induction.

Unit: Same as for Induction.

Retentivity.—The property of a material which is measured by the induction which remains after the removal of an applied magnetic force corresponding to the saturation induction for the material.

Unit: Same as for Induction.

Coercive Force, H_c.—The reversed magnetic force that is just sufficient to reduce the residual induction in a material to zero.

NOTE—When the residual induction is the *normal* residual induction, the coercive force required is called the *normal* coercive force.

Unit: Same as for Magnetic Force.

Coercivity.—The property of a material which is measured by the coercive force required to reduce to zero the induction which remains after the removal of an applied magnetic force corresponding to the saturation induction for the material.

Unit: Same as for Magnetic Force.

REPORT OF COMMITTEE A-7
ON
MALLEABLE CASTINGS

In 1925, Committee A-7 recommended tentatively that the Standard Specifications for Malleable Castings (A 47 – 24)[1] be revised by the addition of a minimum yield point requirement of 30,000 lb. per sq. in. This revision also provided for the determination of the yield point by the drop-of-the-beam of the testing machine. The only criticism that the committee has since received of this tentative revision is that the method of determination of the yield point should be optionally by the drop-of-the-beam or by the divider method.

It is the committee's recommendation, therefore, that the tentative revision[2] of the specifications be amended by the substitution for the words "the yield point shall be determined by the drop of the beam of the testing machine," the words "the yield point may be determined by drop-of-the-beam of the testing machine or by the divider method." It is further recommended that the revision as thus amended be adopted as standard and that the standard specifications be revised accordingly.

The recommendation on advancement to standard of the tentative revisions of the Standard Specifications for Malleable Castings were submitted to letter ballot of the committee with the following results. Affirmative, 20; negative, 3; not voting, 3.

The votes on the proposed amendment of the method of yield-point determination were as follows: Affirmative, 23; negative, 0; not voting, 3.

This report has been submitted to letter ballot of the committee, which consists of 26 members, of whom 20 have voted affirmatively, none negatively, and 6 have refrained from voting.

Respectfully submitted on behalf of the committee,

W. P. Putnam,
Chairman.

Enrique Touceda,
Secretary.

Editorial Note

The tentative revisions of the Standard Specifications for Malleable Castings, amended as recommended by the committee, were approved at the annual meeting and subsequently adopted by letter ballot of the Society on September 1, 1927. The specifications as revised appear in the 1927 Book of A.S.T.M. Standards, Part I.

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[1] 1924 Book of A.S.T.M. Standards.

[2] *Proceedings*, Am. Soc. Testing Mats., Vol. 25, Part I, p. 118 (1925).

REPORT OF COMMITTEE A-8

ON

MAGNETIC ANALYSIS

In addition to the usual meetings held at the time of the annual meeting of the Society, Committee A-8 has held two well attended meetings during the year. At one of these, held at the Research Laboratory of the American Chain Co., in addition to the discussion of the results of the investigation on the properties of high-speed steel which is in progress, a demonstration was given of a new method of magnetic inspection developed by Mr. A. V. de Forest, a member of the committee. This method, which employs the cathode ray oscillograph, is described in detail in a paper appearing as Appendix I to this report, entitled "A Method of Graphic Representation of Magnetic Characteristics." A further discussion of this method and its use is given in a paper by Mr. T. Spooner, entitled "Magnetic Analysis by Means of the Cathode-Ray Oscillograph," appearing as Appendix II to this report.

The development of another device called the duroscope was also announced. This instrument, which is adapted to the testing of magnetic materials over very small areas, was developed in the General Engineering and Testing Laboratory of the General Electric Co. and is described in a paper by Mr. J. A. Sams, entitled "The Duroscope: An Apparatus for the Magnetic Determination of the Durability of Steels," appearing as Appendix IV to this report. Preliminary results of the X-ray examination of a number of the high-speed steel specimens were presented by Mr. Ancel St. John, who is cooperating with the committee in this investigation. These results are recorded in a paper by Mr. St. John, entitled "X-ray Studies of High-Speed Steel," appearing as Appendix III to this report.

The committee also met at Philadelphia in connection with the group meeting of committees held in March. At this meeting, further results of the high-speed steel investigation were received and discussed, and plans made for further work.

Committee A-8 by cooperative investigation and through individual work on the part of its members seeks to promote the development of magnetic analysis and to aid in its practical application to the fullest possible extent. Such development has two phases; the establishment of the fundamental relationships connecting the magnetic properties of ferro-magnetic materials with their mechanical properties, and the development of testing methods best suited to bringing out the significant variations in magnetic properties as affected by the composition, and thermal and mechanical history of the material. It is felt that the most rapid progress is to be made by carrying on these two phases of the problem simultaneously. Without adequate methods of testing, the application of the fundamental principles would be impossible while, on the other hand, the extent to which the tests can be utilized in a practical way is definitely limited by the extent of our knowledge of the underlying relationships.

In view of the fact that the magnetic properties of materials are in themselves complicated and that they are extremely sensitive to many influences, some of which do not affect the mechanical properties to a corresponding degree, it can not be expected that the full solution of the problem will be achieved in a very short time. On the other hand, a number of commercial applications of undoubted value have already been made and the committee feels that through its efforts substantial progress has been made toward the realization of a system of non-destructive testing which in its final development should be of inestimable value to testing engineers and students of the properties of materials.

This report has been submitted to letter ballot of the committee, which consists of 11 members, all of whom have voted affirmatively.

Respectfully submitted on behalf of the committee,

R. L. SANFORD,
Chairman.

A. V. DE FOREST,
Secretary.

APPENDIX I

A METHOD OF GRAPHIC REPRESENTATION OF MAGNETIC CHARACTERISTICS

By A. V. de Forest[1]

The present paper represents a continuation of one phase of the work of Committee A-8 on the magnetic analysis of high-speed steel. Those who have kept in touch with the various papers which have appeared on this subject by members of the committee will have noted a change in procedure in the later tests. This change involves the use of alternating current magnetization epecially directed to the measurement of a magnetic function easy to interpret in terms of heat treatment. It is in contrast to the earlier measurements of the formal magnetic constants and with the attempt to interpret mechanical characteristics in these terms.

In a paper in 1923,[2] a method of magnetization and measurement using alternating current was developed in which a diagram plotted in two dimensions, representing two independent magnetic variables, was shown to be particularly adapted to bring out the mechanical characteristics under study. Results by this method for two different materials were published last year.[3] Although a good discrimination was possible between differences in regard to either of two variables, such as quenching temperature and drawing temperature, the plot was difficult to interpret when others were present. There was also a disadvantage in the length of time necessary to discover the best axis on which to establish the diagram.

To meet these objections and to attempt to provide a more sure and rapid means of recognizing all possible magnetic differences, a method has been developed which graphically represents the shape of the entire hysteresis loop, or the differences between two similar loops. It is evident that in such a diagram, where the magnetizing force is cyclic, all the magnetic and electrical properties involved must leave their mark. Thus, in a balanced circuit, or bridge arrangement such as previously described, in which the sample is balanced against a standard under similar magnetizing conditions, the particular differences between the two can be recognized whether they consist in changes at low or medium or maximum magnetization, or, as explained later, due to a phase shift as the result of a time difference in some characteristic.

The most advantageous axis on which to work appears to be the magnetic flux or differential magnetic flux plotted against a time base at right angles. This timing line is furnished by the alternating current supply used for magnetization.

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[1] Research Engineer, American Chain Co., Inc., Bridgeport, Conn.

[2] A. V. de Forest, "A New Method of Magnetic Inspection," *Proceedings*, Am. Soc. Testing Mats., Vol. 23, Part II, p. 611 (1923).

[3] Haakon Styri, "Testing of Ball Bearing Races by Electric and Magnetic Methods," *Proceedings*, Am. Soc. Testing Mats., Vol. 26, Part II, p. 148 (1926); also de Forest discussion, *ibid*, p. 155.

The work here described was carried out with a cathode-ray oscillograph built by the Western Electric Co.[1] In this device a stream of electrons is projected from one end of a vacuum tube on to a fluorescent screen at the other end where it produces a bright spot. The electron stream is deflected by passing it through an electric or magnetic field, thus causing the spot to travel over a path in which its location with respect to its normal position is an indication of the direction and intensity of the field at that instant. The stream passes between two sets of deflecting plates at right angles to each other, and if recurrent voltage fluctuations of the same frequency are applied to the two sets of plates a plot in rectangular coordinates of the changes of one in terms of the other is the result. If, as is usually the case, one coordinate is made to vary

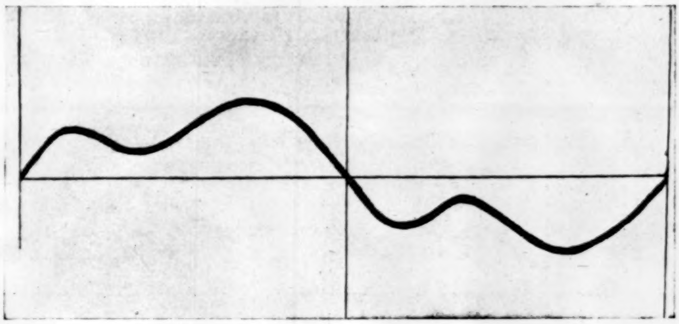
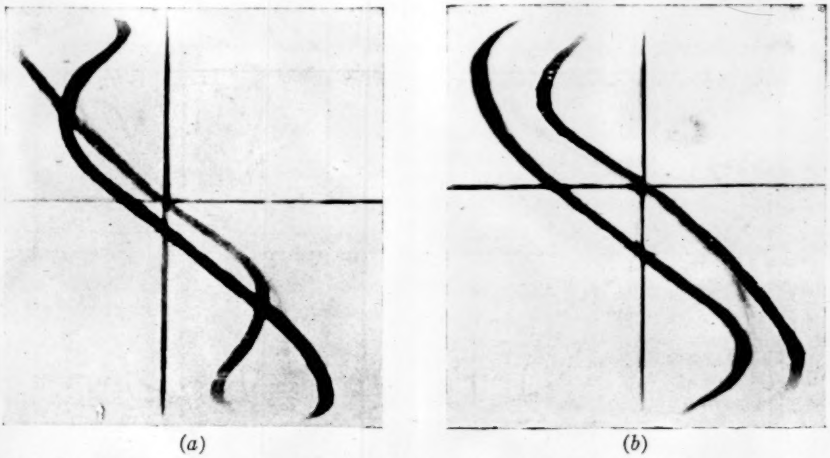


FIG. 1.—Wave Form of Magnetic Difference Between Two Specimens Plotted on Continuous Time Axis.



(a) (b)

FIG. 2.—Two Views of the Former Plot Drawn on Celluloid and Wound into a Cylinder. Showing Effect of Small Phase Shift.

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[1] J. B. Johnson, "A Low Voltage Cathode-Ray Oscillograph," *Phys. Rev.*, Vol. 17, p. 420 (1921).

with the substantially sine wave alternating current to provide a time axis, the other coordinate can be used to study the wave form, amplitude or phase change in a voltage which represents the difference between the magnetic properties of two samples properly placed in similar coils. The timing wave is most conveniently fed from a phase shifter which permits of any desired adjustment of coincidence between the magnetizing force and induced electromotive force. By this means the part of the figure representing maximum or minimum induction may be adjusted to the center of the pattern, or the significant changes can be separated from those of lesser importance. The effect of shifting the phase of the timing wave can be seen in the diagram in Fig. 1. When both waves are sinusoidal and in phase with each other, and of equal magnetitude, the resulting pattern is a straight line at 45 deg. in the first and third quadrants. When one is displaced by 180 deg., the line is in the second and fourth quadrants. At 90 deg. phase difference the graph is a circle; other phase angles are shown by the size and position of the resulting ellipse. Small changes of phase in a simple graph of the difference between two magnetic specimens are shown in Fig. 2.

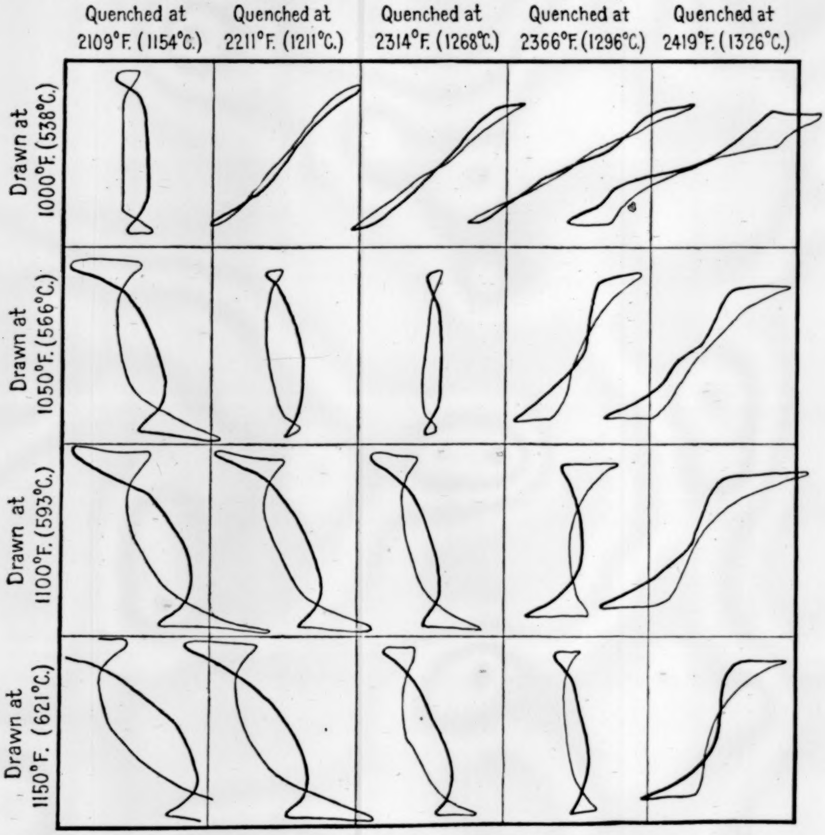

FIG. 3.—Oscillograms of A.S.T.M. High-Speed Steel Bars. Quenched and Drawn to Various Temperatures.

Here the wave form is drawn as it would be seen in an oscillograph record of the usual type. The diagram is drawn on celluloid, and when this is wound into the form of a cylinder, the plot appears as it does in the system of coordinates here described. A shift in the phase of the timing line is equivalent to rotating the cylinder about its axis. This effect is shown in Fig. 2, and the different appearance of the diagram due to a small phase shift is readily seen. In the subsequent diagrams, Figs. 3 to 6, one side of the loop is shaded to distinguish the "front" half cycle from the "rear" half cycle. A little study of the model shows how the more significant parts of the curve may be emphasized by selecting a phase which brings them near the central axis.

Applying this method to the high-speed steel bars, prepared for the committee by the Westinghouse Electric and Manufacturing Co. and described last year,[1] a series of patterns are found in which it is possible to trace out the differing effects of both quenching temperature and drawing temperature. Figure 3 shows these graphs arranged so that the patterns of equal drawing temperature are arranged horizontally and those for equal quenching temperature vertically. Inspection of these diagrams as so arranged shows progressive changes from one treatment to another along either direction. Any considerable difference in type of graph can be checked by reference to those on each side and above and below. In certain cases the patterns for individual bars did not seem to fit in with the general scheme. Several of these are shown in Fig. 4. In the first, bar G – 9 appears to have been quenched at too high a temperature; it greatly resembles G – 6, supposedly quenched at 50° F. higher. The same method of comparison has been used by Spooner using much higher magnetizing forces and with wholly different patterns and has led him to similar

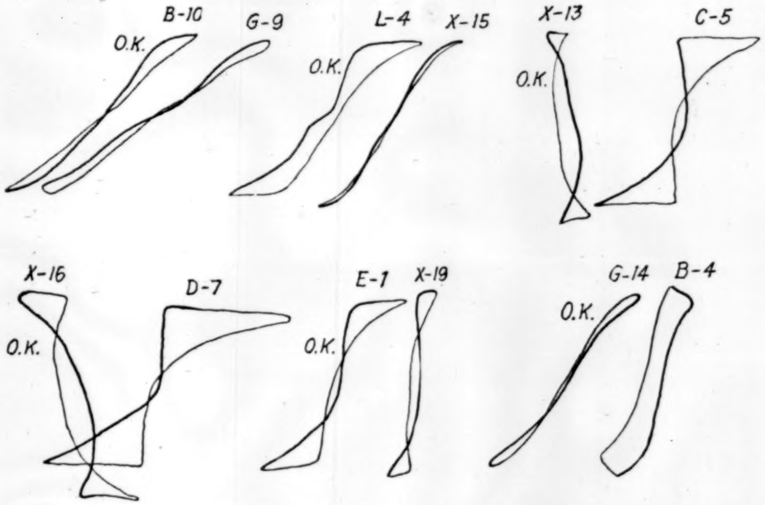

FIG. 4.—Oscillograms Showing Differences Between Bars of the Same Heat Treatment.

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[1] Thomas Spooner, "The Magnetic Analysis of High-Speed Steel," *Proceedings*, Am. Soc. Testing Mats., Vol. 26, Part II, p. 116 (1926).

conclusions as to these specimens. An inspection of previous data obtained on these bars before the drawing operation confirmed this result. For some reason the structure of G - 9 has responded equally to a quench from 2314° F. as G - 6 to the high temperature of 2366° F. Again, another pair with the same heat treatment gave different patterns, X - 15 and L - 4. After quenching alone, X - 15 appeared in the direction of higher quench. C - 5 and X - 13, D - 7 and X - 16, E - 1 and X - 19 show the same kind of difference both in this work and that of Spooner. To offset these cases of concordant differences, B - 4 and G - 14 are shown. Here, all other tests indicate nothing abnormal. Further examination is needed to clear up this particular case.

Another set of curves is shown in Fig. 5. These are made from a set of cutters supplied by the S. K. F. Industries and on which Sams has applied the Duroscope. The outstanding differences here are those between specimen No. 2 and its group, and No. 16 and its group. The causes for these large variations will probably be explained, when cutting and other tests are made; or the study of magnetic results on a larger number of specimens, in which the drawing temperature is represented, may help to clear up the matter. The patterns show, however, that important differences may be present in test samples, prepared carefully for laboratory tests. With these diagrams in mind, the results obtained for specimens No. 2 and 16 would not be included in averages representing the others of those groups.

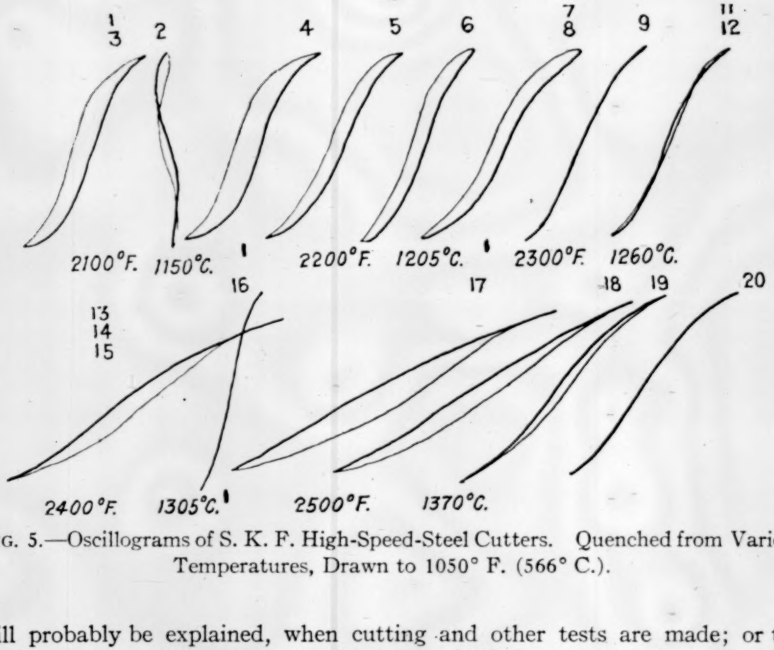

FIG. 5.—Oscillograms of S. K. F. High-Speed-Steel Cutters. Quenched from Various Temperatures, Drawn to 1050° F. (566° C.).

In the work here described, the cathode-ray oscillograph was used, but other types of oscillographs may be arranged to give diagrams in the same coordinates. For instance, the two-dimensional oscillograph, developed at the Electrical Research Laboratory of the Massachusetts Institute of Technology may be used; or a timing mirror may be combined with any ordinary single element unit and driven by a vibrating system or a synchronous motor. A system of vacuum tube amplification may be readily adapted to provide ample sensitivity.

This graphic method has great advantages when magnetic analysis is applied to commercial material of necessarily broad tolerances with respect to size, composition and treatment. Take, for instance, the case of a drop forging of irregular section shown in Fig. 6. Such forgings are made from a medium-carbon steel of rather varying composition. Occasionally a low-carbon bar may be forged up through accident. The dimensions, especially thickness, vary largely. The forging temperature varies, and is responsible for brittleness which is not removed by subsequent heat treatment. The final heat treatment varies in both quench and draw, and may mask the effects of forging conditions so far as ordinary tests are concerned. With these complications, even the method of double readings at selected phases on the alternating current galvanometer failed to separate all the variables. After a study of the various patterns found in the commercially treated forgings, a similarity in shape, re-

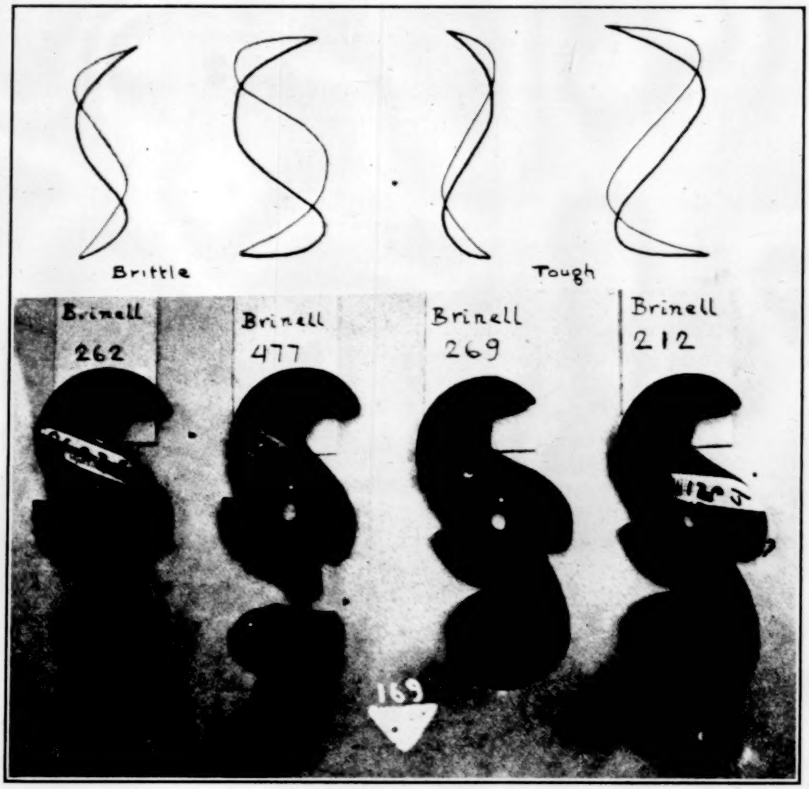

FIG. 6.—Oscillograms of Small Forgings. Showing Magnetic Differences Between Tough and Brittle Specimens of Same Brinell Hardness.

gardless of size, was found to indicate brittleness, quite regardless of Brinell hardness. Figure 6 shows two samples of Brinell 262 and 477 broken with brittle fracture, and two others with numbers of 269 and 212, quite tough, and bent to a considerable angle. In this case so many variations in mechanical properties and in magnetic characteristics are present, that years of work would be required to correlate all the factors involved; but through the ability to recognize and isolate peculiarities of pattern found especially to indicate particular brittleness or insufficient toughness, the graphic method became capable of successful application as a routine test.

So far as is known all the variables affecting the mechanical behavior of a ferro-magnetic material have their reflection in the magnetic properties. In somewhat the same way it could be said that they also affect the stress-strain diagram, and if these relations could be studied sufficiently all the factors involved could be deduced therefrom. The magnetic diagram, however, can be more accurately and readily produced, and is sensitive to many factors which have but little influence on the stress-strain relations. By using suitable magnetization and phase adjustment, certain factors may be either emphasized or ignored. Graphic magnetic analysis presents for the first time both a sythesis of the mechanical properties, and the possibility of selecting from these the particular characteristics of importance to the solution of any one problem.

[For a discussion on magnetic analysis by means of the oscillograph, see page 260.—ED.]

APPENDIX II

MAGNETIC ANALYSIS BY MEANS OF THE CATHODE-RAY OSCILLOGRAPH.

By Thomas Spooner[1]

Introduction:

Last year, the author presented before this Society a paper on the Magnetic Analysis of High-Speed Steel.[2] Since that time Mr. A. V. de Forest has devised a new method of magnetic inspection, using the cathode-ray oscillograph which has certain features which make it particularly suitable for the testing of heat-treated steel. Mr. de Forest is describing his method and is giving certain test data which he has obtained in a paper presented at this annual meeting.[3] The purpose of this paper is to supplement his results with others obtained under somewhat different conditions and to give a more detailed explanation of the principle of operation of the test method.

Test Method:

The same magnetic circuit and coil arrangements were used for these tests as were described in the previous paper[2] except that the coils on the samples in the present case had several thousand turns and were connected to one pair of plates of a Western Electric cathode-ray oscillograph instead of to the alternating current galvanometer. The other pair of oscillograph plates was connected to the phase-shifting transformer circuit which in the former apparatus supplied the galvanometer field. This arrangement differs from that used by de Forest in that the magnetic circuit is closed and therefore much higher inductions in the samples may be obtained.

Principle of Operation:

Neglecting the effect of eddy currents, this type of test shows nothing which cannot be deduced from the original hysteresis loops of the standard and unknown samples. However, it emphasizes certain of the hysteresis-loop characteristics which heretofore have not been given much prominence, and gives a picture which is a function of the whole hysteresis loop rather than picking out one factor such as mean permeability, hysteresis loss, etc., as has often been done with the previous types of test.

In order to show just what this test indicates we have taken several pairs of hysteresis loops and obtained by means of a graphical analysis corresponding patterns such as would be given by the cathode-ray oscillograph. This brings out very clearly just what characteristics are being emphasized by this type of test.

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[1] Research Engineer, Westinghouse Electric and Manufacturing Co., East Pittsburgh, Pa.

[2] Thomas Spooner, "The Magnetic Analysis of High-Speed Steel," *Proceedings*, Am. Soc. Testing Mats., Vol. 26, Part II, p. 116 (1926).

[3] A. V. de Forest, "A Method of Graphic Representation of Magnetic Characteristics," see p. 234.

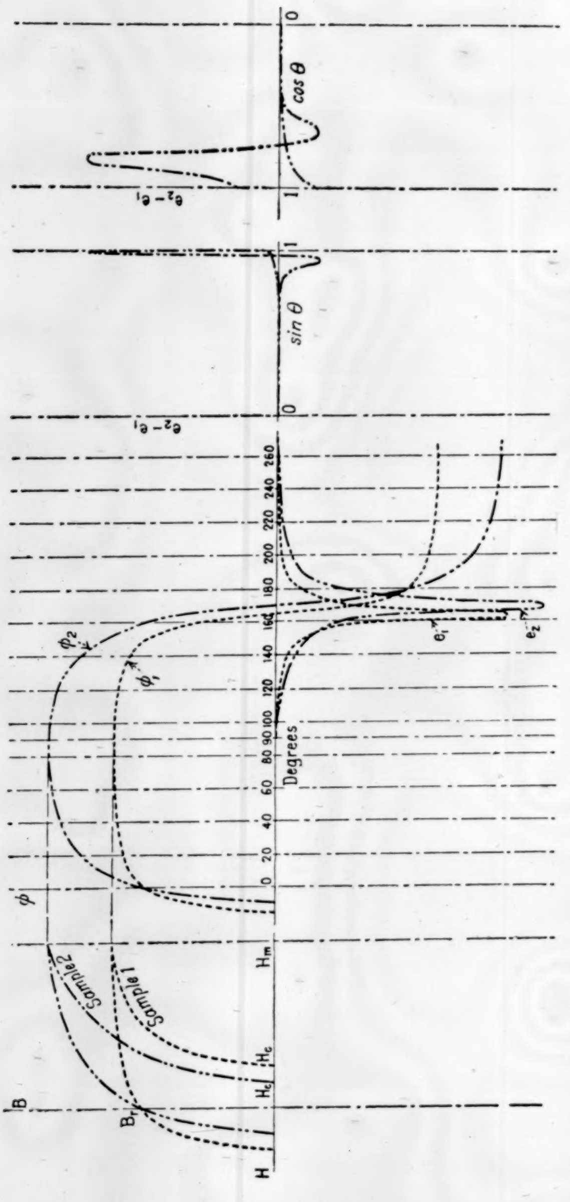

FIG. 1.—Illustrating Method of Obtaining de Forest Patterns from Hysteresis Loops.

Figure 1 illustrates the process. At the left are shown two hysteresis loops which are assumed to correspond to the standard and unknown samples which are under consideration. Sample 1 has a lower permeability at the maximum induction than does sample 2, but the retentivity values *B*r are identical. Sample 1 has a higher coercive force, *H*c, than sample 2. Sample 1 is therefore a harder material than sample 2 and would correspond to a specimen having a higher quenching temperature or a lower drawing temperature for the same chemical composition.

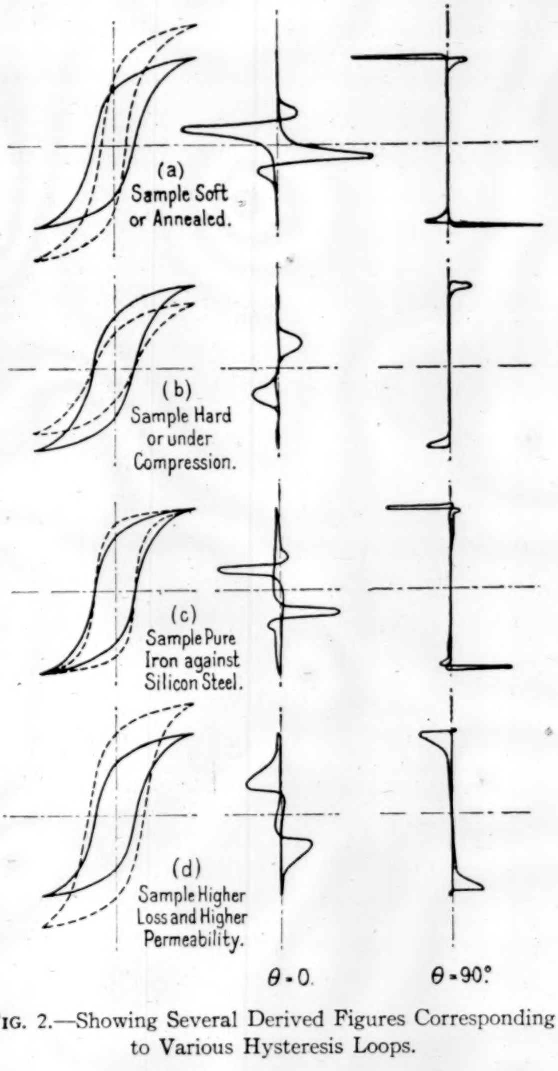
(a)
Sample Soft or Annealed.
(b)
Sample Hard or under Compression.
(c)
Sample Pure Iron against Silicon Steel.
(d)
Sample Higher Loss and Higher Permeability.
$\theta = 0.$
$\theta = 90°$

FIG. 2.—Showing Several Derived Figures Corresponding to Various Hysteresis Loops.

Now assume that both of the samples have the same sine wave magnetomotive force applied to them. The corresponding flux waves are given by

ϕ_1 and ϕ_2. Now since each sample is surrounded by an exploring coil there will be induced in each coil a voltage which at any instant is proportional to the rate of change of flux or, in other words, the voltage is proportional to the differential of the flux wave or at any instant to the slope of the flux wave. The corresponding voltage waves are given by e_1 and e_2. Finally the voltage applied to the cathode-ray oscillograph is equal to the difference between e_2 and e_1. This difference has been plotted at the right against a sine wave for the other coordinate for two phase angles of the sine wave, 90 deg. apart. In these two resulting figures the sine-wave variation is horizontal and the difference of the voltage waves is vertical. It will be noted that only one-half of the complete figure is shown, the other half being identical but reversed.

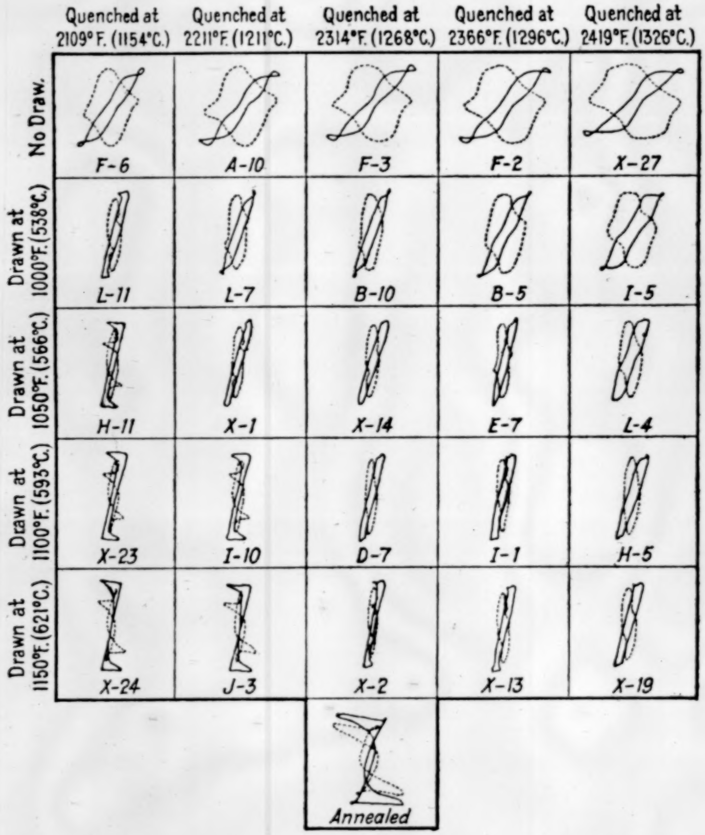
Quenched at 2109°F. (1154°C.)
Quenched at 2211°F. (1211°C.)
Quenched at 2314°F. (1268°C.)
Quenched at 2366°F. (1296°C.)
Quenched at 2419°F. (1326°C.)
No Draw.
Drawn at 1000°F. (538°C.)
Drawn at 1050°F. (566°C.)
Drawn at 1100°F. (593°C.)
Drawn at 1150°F. (621°C.)
F-6
A-10
F-3
F-2
X-27
L-11
L-7
B-10
B-5
I-5
H-11
X-1
X-14
E-7
L-4
X-23
I-10
D-7
I-1
H-5
X-24
J-3
X-2
X-13
X-19
Annealed

FIG. 3.—Results of Retest of High-Speed Bars Using New Method.

Dotted figures produced by shifting sine wave 90 deg.

Figure 2 shows several of these derived figures corresponding to various hysteresis loops. Their similarity to some of the cathode-ray oscillograph patterns shown by Mr. de Forest and later in his paper should be noted. In

Fig. 2 the sine wave is vertical instead of horizontal. In all four cases the same hysteresis loop is taken as the standard, namely, the one shown by the full line. Case (*a*), at the top, shows a test sample having a higher permeability and lower coercive force than the standard. This corresponds to a soft or annealed specimen. In case (*b*) the sample has a lower permeability and for equal maximum inductions would have a higher coercive force than the standard.

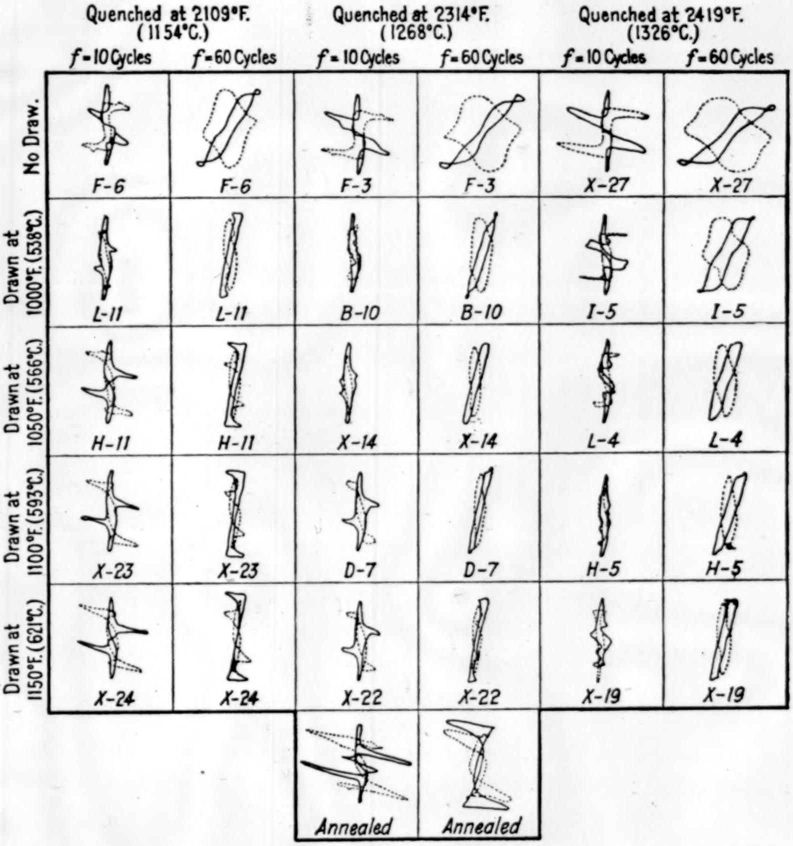

FIG. 4.—Comparison of the Effect of Eddy Currents at 10 Cycles and at 60 Cycles.

Dotted figures produced by shifting sine wave 90 deg.

This corresponds to a sample which is hard or under compression. Case (*c*) shows the loop for a specimen which has the same permeability at maximum induction and the same coercive force as the standard. The shape of the loop is different, however, the retentivity being higher for the test specimen. This corresponds approximately to the difference which may be found between pure iron and silicon steel, the sample with the higher retentivity corresponding to the pure iron. Case (*d*) is for a sample having a higher permeability and higher coercive force than the standard and therefore a higher hysteresis loss. This corresponds to two specimens having different chemical compositions. The test sample might in this case have a higher carbon content.

Now what is the chief cause which produces these characteristic figures? An examination of Figs. 1 and 2 will show that the magnitude of the peaks in the figures is largely proportional to the slopes of the hysteresis loops as the flux passes through zero. Steep slopes which in general correspond to soft or low-loss specimens produce large peaks. Again whether these peaks occur at the left or right depends upon the phase angle of the flux wave and this in turn is determined by the coercive force or hysteresis loss as well as by the slope. For the conditions of Fig. 2 and the same chemical-composition peaks to the left above the zero line correspond to soft material and to the right to hard material.

It should be remembered that eddy currents tend to slow down any sudden change of flux and therefore for samples with large cross-sections or for high frequencies, these peaks are not so pronounced.

Test Results on High Speed Bars:

Many of the high-speed bars on which results were reported last year have been retested, using this new method. The bars were a little less than $\frac{1}{2}$ sq. in. in section.

Figure 3 shows some of these results. All of the specimens with the same drawing temperature are arranged in a horizontal line and those with the same quenching temperature in a vertical line. Therefore, by following across horizontally the effect of quenching may be noted and by moving vertically the effect of drawing will most readily be made evident. These patterns should be compared with the figures obtained by Mr. de Forest, using an open magnetic circuit and lower inductions. The samples for the two sets of figures are not the same in all cases. An annealed specimen is shown at the bottom for comparison. The maximum induction of the standard sample was about 7 kilogausses for the results shown in Fig. 3. It should be noted that for a given drawing temperature the patterns in general widen out as the quenching temperature is increased and for a given quench become narrower as the drawing temperature is increased. The effects are progressive and no sample is much out of line. As pointed out by Mr. de Forest, in two or three cases the samples were evidently not heat-treated at quite the temperature shown by the chart. One point of particular interest is that a higher quenching temperature and a higher drawing temperature give much the same pattern as for a lower quench and a lower draw. In order to make such a comparison, follow the figures downwards diagonally from left to right.

In order to illustrate the effect of eddy currents, certain samples were tested at 10 cycles as well as at 60 cycles. A comparison is given in Fig. 4. The same bars tested at the two frequencies will be found side by side. For the lower frequency the peaks are much greater, as indicated above, since the eddy currents are smaller and therefore are not so effective in damping the flux changes. Thin samples at 60 cycles show these large peaks as given by the high-speed bars at 10 cycles.

APPENDIX III

X-RAY STUDIES OF HIGH-SPEED STEEL

By Ancel St. John[1]

A year ago, arrangements were made for cooperation between the author's X-ray laboratory and Committee A-8 on Magnetic Analysis. In accordance with these arrangements, diffraction patterns have been secured for many of the samples referred to in the discussion on magnetic analysis that took place at the 1926 Annual Meeting of the Society.[2] The results throw some light on the possible causes of some of the phenomena reported upon at that time.

The diffractometers used were of the type originally designed and constructed by the author for the Union Carbide and Carbon Research Laboratories. The usual technique for the surface reflection method was followed for the most part. The specimens were rectangular blocks previously used for micrographic, hardness and density tests. They were mounted so that one edge was on the axis of the diffractometer and a polished face was at an angle of about 5 deg. with the X-ray beam. This face was usually $\frac{1}{2}$-in. wide and so gave rise to rather broad lines. In a few cases, narrow specimens were available and the lines were correspondingly sharp. An attempt was made to prepare from these blocks very narrow specimens so as to secure very sharp lines, but time and equipment for doing this without overheating and possibly altering the condition of the specimen were lacking. Some of the results are depicted in the accompanying illustrations. The negatives, of course, disclose many details which are not adequately reproduced in the half-tones.

Figure 1 presents the patterns for a series of specimens in the original "normalized" condition and after being quenched from various temperatures. Photomicrographs of all these specimens were shown in the paper by Thomas Spooner on "The Magnetic Analysis of High-Speed Steel" included in the 1926 discussion already referred to. G-4 was a normal specimen and K-10 a specimen showing abnormal magnetic and physical properties and found to have an abnormal chemical analysis (14 per cent of tungsten instead of 17.3 per cent). Both were in the original state after normalizing at 1650° F. (899° C.). Both patterns consist principally of the body-centered cubic pattern of ferrite with a fairly strong auxiliary pattern due to the carbides. G-4 shows faint signs of the austenite pattern but K-10 shows little or none. The lines for K-10 are not so sharp as for G-4, indicating smaller grain size as disclosed in the micrographs, and the auxiliary patterns differ somewhat, indicating modified composition as disclosed by the chemical analysis. These two features are brought out more fully in Fig. 2, which is a comparison of the patterns of these two specimens in the region beyond the end of the portion shown in Fig. 1. A special technique was used to secure sharp lines in Fig. 2, so the two neighboring wave-lengths constituting the alpha doublet of the molybdenum radiation used are resolved into a pair of nearby lines. The first line marked in the continuation of the ferrite pattern is the last line marked in the ferrite pattern in Fig. 1. In Fig. 2 the difference in sharpness of the lines is very apparent and the lines of the auxiliary pattern do not register with each other as they should if the carbides were identical. The difference in chemical composition is thus associated for this heat treatment with modification of

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[1] Consulting Physicist, Long Island City, N. Y.

[2] See Report of Commttee A-8 on Magnetic Analysis, *Proceedings*, Am. Soc. Testing Mats., Vol. 26, Part I, p. 157 (1926); also, paper by Thomas Spooner entitled "The Magnetic Analysis of High-Speed Steel"; paper by Haakon Styri entitled "Testing of Ball Bearing Races by Electric and Magnetic Methods;" *Proceedings*, Am. Soc. Testing Mats., Vol. 26, Part II, pp. 116 to 176 (1926).

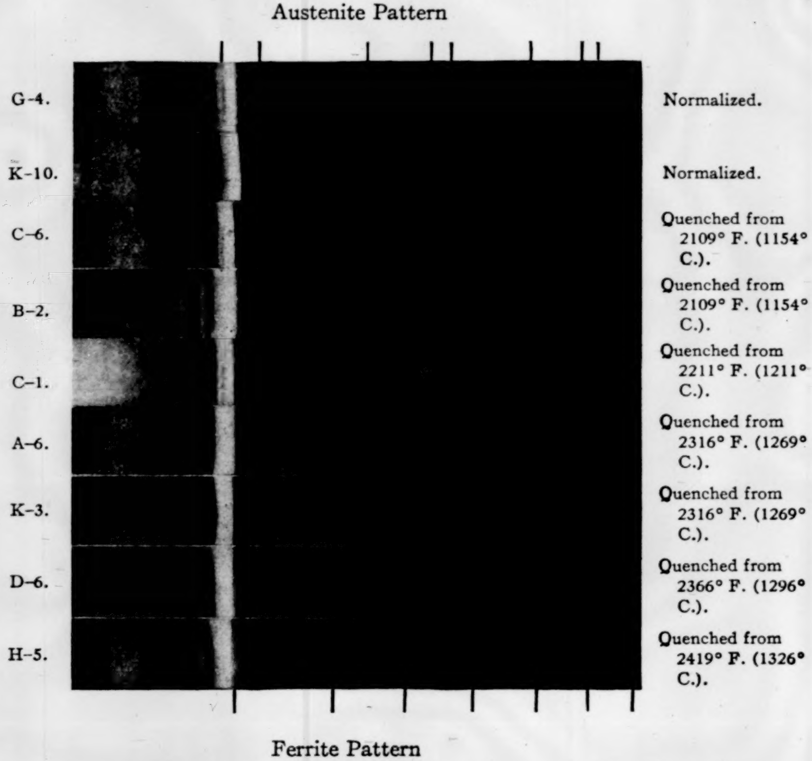
Austenite Pattern
G-4.
Normalized.
K-10.
Normalized.
C-6.
Quenched from 2109° F. (1154° C.).
B-2.
Quenched from 2109° F. (1154° C.).
C-1.
Quenched from 2211° F. (1211° C.).
A-6.
Quenched from 2316° F. (1269° C.).
K-3.
Quenched from 2316° F. (1269° C.).
D-6.
Quenched from 2366° F. (1296° C.).
H-5.
Quenched from 2419° F. (1326° C.).
Ferrite Pattern

FIG. 1.—X-ray Patterns for Material as Quenched Before Drawing.

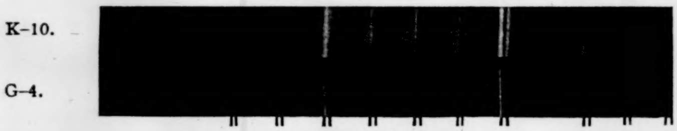

FIG. 2.—Continuation of Ferrite Pattern Shown in Fig. 1 for Specimens K-10 and G-4.

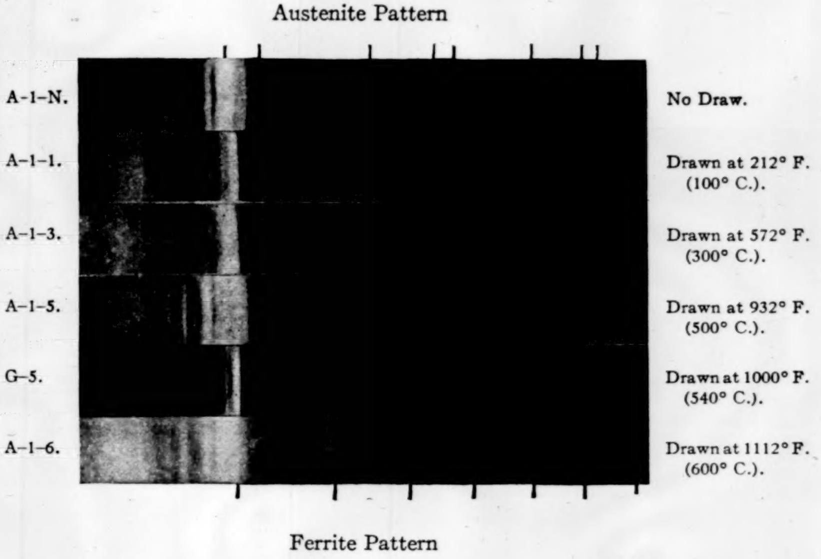
Austenite Pattern
A-1-N.
No Draw.
A-1-1.
Drawn at 212° F. (100° C.).
A-1-3.
Drawn at 572° F. (300° C.).
A-1-5.
Drawn at 932° F. (500° C.).
G-5.
Drawn at 1000° F. (540° C.).
A-1-6.
Drawn at 1112° F. (600° C.).
Ferrite Pattern

Fig. 3.—X-ray Patterns for Material as Quenched at 2100° F. (1150° C.).

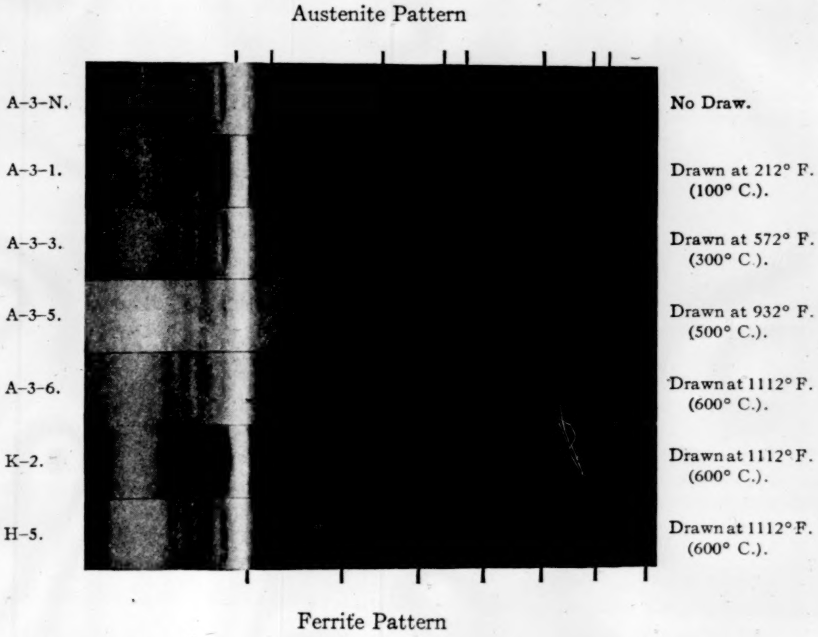
Austenite Pattern
A-3-N.
No Draw.
A-3-1.
Drawn at 212° F. (100° C.).
A-3-3.
Drawn at 572° F. (300° C.).
A-3-5.
Drawn at 932° F. (500° C.).
A-3-6.
Drawn at 1112° F. (600° C.).
K-2.
Drawn at 1112° F. (600° C.).
H-5.
Drawn at 1112° F. (600° C.).
Ferrite Pattern

Fig. 4.—X-ray Patterns for Material as Quenched at 2419° F. (1326° C.).

austenite content and modification of carbide structure. C-6 and B-2 were both supposed to have been quenched at 2109° F. (1154° C.) but show distinctly different characteristics under the microscope which tend to confirm the magnetic test in suggesting a higher actual quenching temperature for B-2. To some extent the patterns support this as the austenite lines seem better defined but certain other lines appear which are lacking in all the other patterns suggesting that the observed effects may be due to composition rather than to heat treatment. C-1 was a specimen only $\frac{1}{8}$-in. wide, hence the lines are narrower but otherwise consistent with the higher quenching temperature. A-6 and K-3 were specimens of normal and abnormal composition, respectively.

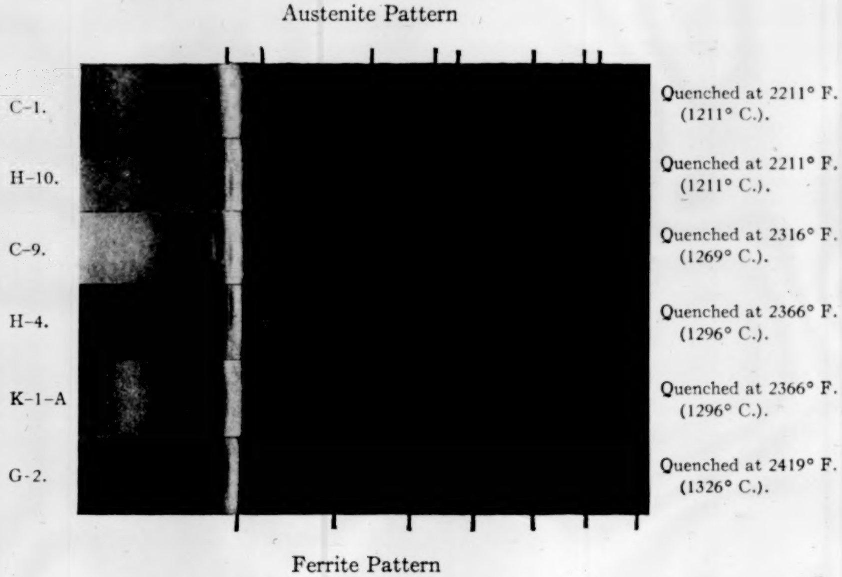
Austenite Pattern
C-1.
H-10.
C-9.
H-4.
K-1-A
G-2.
Quenched at 2211° F. (1211° C.).
Quenched at 2211° F. (1211° C.).
Quenched at 2316° F. (1269° C.).
Quenched at 2366° F. (1296° C.).
Quenched at 2366° F. (1296° C.).
Quenched at 2419° F. (1326° C.).
Ferrite Pattern

FIG. 5.—X-ray Patterns for Material as Drawn at 1050° F. (566° C.).

In the latter the austenite pattern is less pronounced, agreeing with the magnetic indication of lower quenching temperature, but the differences in the auxiliary patterns already noted for the normalized specimens is again evident, indicating that the reduced austenite content is to be attributed to composition rather than to heat treatment. In D-6 and H-5 the austenite pattern is progressively more pronounced, as might be expected for the higher quenching temperatures.

Figure 1 thus shows that as the quenching temperature is increased for the same composition the intensity and sharpness of the austinite pattern increases, indicating both increasing quantity and increasing grain size of the austenite content. This is consistent with the micrographs. It also shows that change of composition may offset the effect of heat-treatment.

Figure 3 presents patterns of a series of specimens quenched at 2100° F. (1150° C.) and then drawn at various temperatures. At this quenching temperature the austenite pattern is weak and hazy, but a prominent line, the second, can be readily observed at all draws except the highest and is even faintly perceptible in this. The specimen G-5 was only $\frac{1}{8}$-in. wide, giving narrower lines, but otherwise this pattern is normal. The series indicates that for this quenching temperature there is a decided tendency for austenite to persist at high drawing temperatures.

Figure 4 presents a similar series for material quenched from 2419° F. (1326° C.) which shows first a considerable quantity of well-developed austenite. The austenite is notably present through the 932° F. (500° C.) draw and in the higher draw for the abnormal specimen K-2 but is markedly absent in the higher draw for the two normal materials A-3-6 and H-5. K-2 again shows the differences in the auxiliary patterns already noted for abnormal stock. There are some indications that the austenite pattern becomes somewhat less sharply defined as the drawing temperature is increased, suggesting that the austenite is being disintegrated though not yet transformed. The series as a whole shows that a temperature between 932° F. (500° C.) and 1112° F. (600° C.) is sufficient to eliminate the austenite from normal stock but that a higher temperature would be required for the abnormal material.

Figure 5 presents patterns for a series of specimens drawn at 1050° F. (566° C.) after various quenches. With the exception of K-1-A, the austenite pattern has disappeared. Its persistence in this specimen indicates either that the specimen was not heat treated as stated in the record or that the change in composition has raised the temperature required for eliminating the austenite. Patterns H-10, C-9, H-4 and G-2 were made from narrow specimens giving correspondingly narrow lines. The ferrite and carbide lines are sharper, as the quenching temperature is higher, indicating larger grain size in support of the micrographs. C-1 and H-10 both had the same treatment, so the patterns are identical except for differences due to the width of the specimens. The disappearance of the austenite pattern except for the K sample confirms the magnetic test in selecting this drawing temperature as satisfactory for normal material.

Not enough data are yet available for a complete solution of the relations between internal structure, mechanical properties, magnetic properties and heat treatment. But the evidence in hand suggests very strongly that the presence or absence of austenite is of major importance and that the magnetic tests are satisfactory because they give a quick indication as to this factor.

APPENDIX IV

THE DUROSCOPE: AN APPARATUS FOR THE MAGNETIC DETERMINATION OF THE DURABILITY OF STEELS

By J. A. Sams[1]

Object:

The suitability of a steel for a specific use, such as tools, cutters, dies, etc., is determined by hardness tests. As no criterion of hardness has been established these tests are of different kinds. Various physical properties, offering resistance to change in form, and associated with what is popularly called hardness, are therefore regarded as a measure of hardness in a physical sense. These tests include measurements of:

1. Resistance to wear,
2. Resistance to shock,
3. Resistance to pressure,
4. Elasticity.

It has been the practice heretofore to test for the hardness of tools and cutters by the Brinell and scleroscope methods. Predictions of durability are not based upon the results of these hardness tests alone. Due consideration is given to the chemical composition and conditions of manufacture of the steel which experiment and experience have found helpful in the making of durable products, as well as to its consequent structure.

As the magnetic characteristics of a steel vary with its structure and composition, a magnetic method has been devised and an apparatus, known as the Duroscope, constructed for testing steel as a finished product, or in various stages of its manufacture, to determine whether its properties are normal for steel of that description and treatment. In addition to doing what it was originally designed for, it promises to be capable of other tests, such as determining the relative hardness of magnetizable objects in general, in some cases the chemical composition, and to aid in a general way in the study of the structure and properties of the material.

As the purpose of this particular development was to perfect an instrument for the determination of the suitability of tools and cutters, this paper is limited to this particular application, and the investigation has been conducted thus far only with tool steel.

Development of the Duroscope:

In the development of the Duroscope the first experiments were tried with such apparatus as was readily available in the laboratory, although it was not best adapted for the work. These experiments were of the following types:

1. Ballistic tests with galvanometer and exploring coils.
2. Magnetic tests with compass needle.

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[1] **General Engineering and Testing Laboratory, General Electric Co., Schenectady, N. Y.**

3. Loss measurements with instruments of the wattmeter type.
4. Resistivity measurements.

The above experiments indicated the possibility and suggested the design of a magnetic duroscope and an experimental model was constructed accordingly.

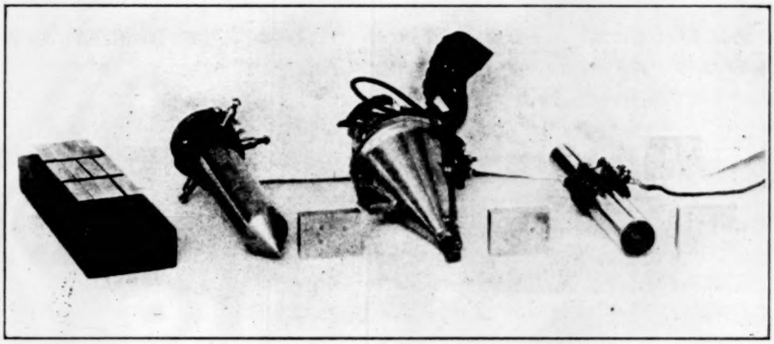


FIG. 1.—Magnetic Duroscope Testing Instruments and Standard Specimens.

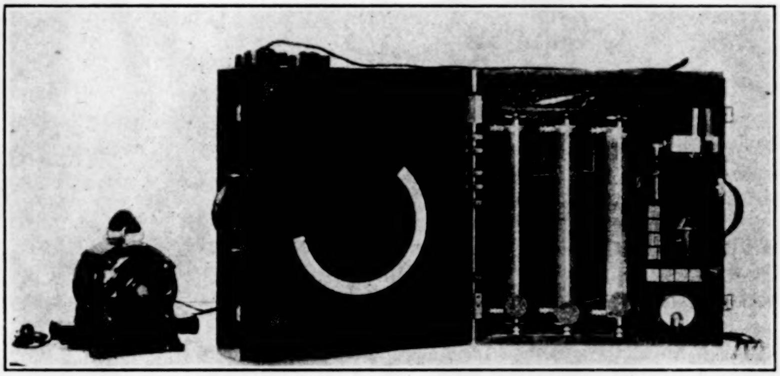


FIG. 2.—Magnetic Duroscope.

Working Principle of the Magnetic Duroscope in Its Present Form:

The principle of the apparatus is based on the measurement of loss in the test sample under the influence of alternating magnetizing forces. Accurate measurement of real loss is, however, unnecessary. What the duroscope indicates is a quantity related in a certain way to the true loss in the specimen, and the test consists in comparing the apparent loss of the several test specimens. The comparison of the specimens can be made either by comparison of the corresponding deflections of the wattmeter or differentially by working the two specimens against one another. In the latter case, the wattmeter indicates the difference between the specimens. If the two specimens are exactly alike, the indication of the wattmeter will be nil. The method for obtaining a nil deflection by use of an auxiliary specimen whose loss character can be varied at will is called a compensation method. The essential part of the Duroscope is the electromagnet for magnetizing the specimen combined with a potential coil for measuring the apparent loss. For convenience this part is called the duroscope tester or pencil.

For testing material for service, any of the following principles may be used:

1. Uncompensated.
2. Externally Compensated.
3. Self Compensated.
4. Differential.

In the particular application where it is desired to determine the suitability of tools and cutters the compensated and differential methods are preferred.

The uncompensated tester consists primarily of an alternating current electromagnet, the armature of which is the specimen to be tested. The magnetizing current is passed through the current coil of a wattmeter indicator. The potential coil of the tester is connected to the potential element of the indicator.

After numerous trials the form of the electromaget chosen was of the concentric pole type, thus confining the flux to the spot covered by the tester with practically no leakage flux. This is important where it is desired to test close to the edge of a specimen.

There are at present three types of testers. Each has its particular use. Testers for any special purpose can be made to meet the desired requirements. The choice of the tester depends upon the nature of the specimen. Each tester may be used with or without compensation as necessary. The three types of testers at present are: (1) Cone shaped; (2) Cylindrical; and (3) Pointed. Figures 1 and 2 are illustrations of the Duroscope.

The cone-shaped type has a small polar area where it makes contact with the specimen. It was the first developed, but was later supplemented by the cylindrical type; it is self compensating and has a large polar area. It is possible on account of the balanced electrical and magnetic construction to compare two samples simultaneously. Both the cone-shaped and cylindrical types require the test specimen to have a well-finished plane surface.

For rounded or uneven surfaces the pointed tester is best adapted. All three types are available for the nil method, by the use of an auxiliary compensator, and the cylindrical type has the further advantage of having provision for internal compensation.

The compensator is a variable transformer with part of the magnetizing coil capable of adjustment so as to give a variable amount of indicated loss. The tester and compensator are connected in series with the potential coils in opposition. The wattmeter tends to give a positive deflection for the losses due to the test sample including the loss of tester itself, and the compensator tends to produce simultaneously a negative deflection. When the compensation is exact the deflection is nil. It has been found by experience that when the compensator is adjusted for the normal voltage and frequency a small variation of voltage or frequency does not upset the equilibrium. The quality of the sample is indicated by the setting of the compensator for exact equilibrium, and the calibration of the compensator is made by specimens of known quality, that is, by specimens of a known grade of steel chilled at the required temperature and tempered at different temperatures. For the scheme of wiring see Fig. 3.

Internal Compensation:

The cylindrical type of tester is also equipped with a compensator at one end in place of a sample. It has all the advantages of the above described compensator with the further advantage of making the instrument self contained. This compensator consists of a movable plunger capable of adjustment with the help of a micrometer.

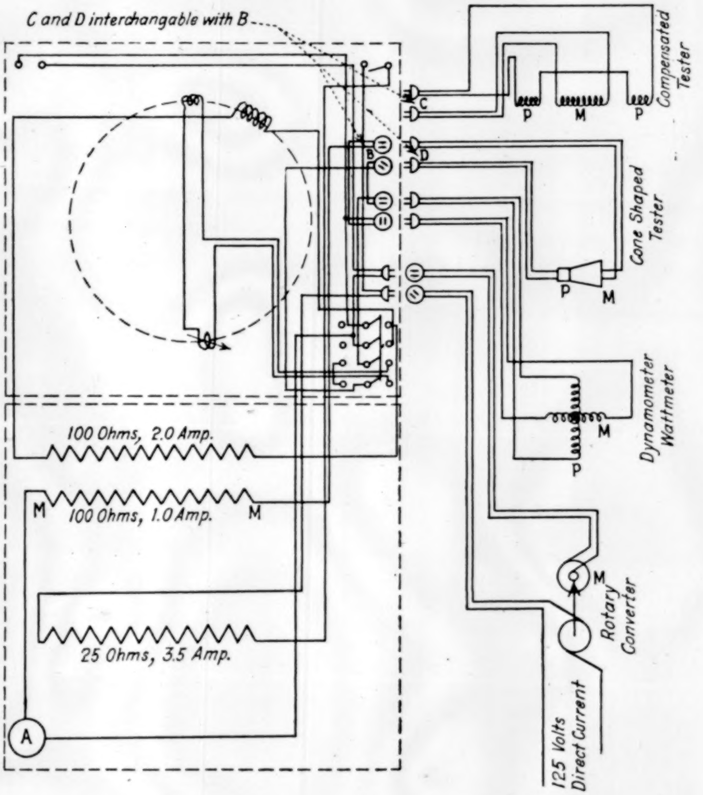

C and D interchangable with B
C
P
M
P
Compensated Tester
B
D
Cone Shaped Tester
P
M
Dynamometer Wattmeter
M
P
Rotary Converter
M
125 Volts Direct Current
100 Ohms, 2.0 Amp.
M
100 Ohms, 1.0 Amp.
M
25 Ohms, 3.5 Amp.
A

FIG. 3.—Connection Diagram for Magnetic Duroscope.

Results of Tests:

The durability of a cutter may be determined by its comparison with other cutters in service. The cutters may then be classified according to their relative condition. These tests are being made as a means of verifying the predictions based on Duroscope tests. They are, however, incomplete, and conclusive results cannot be given at this time. The results of part of one test are shown graphically in Fig. 4.

The teeth were of the inserted type and were classified according to their relative condition, by inspection, after a run in service, the inspector being ignorant of the Duroscope predictions. At the time of this inspection, the teeth were only slightly damaged and were put back in service for another run.

A comparison of Duroscope, Brinell, Rockwell and scleroscope tests on sixteen high-speed steel specimens was also made.

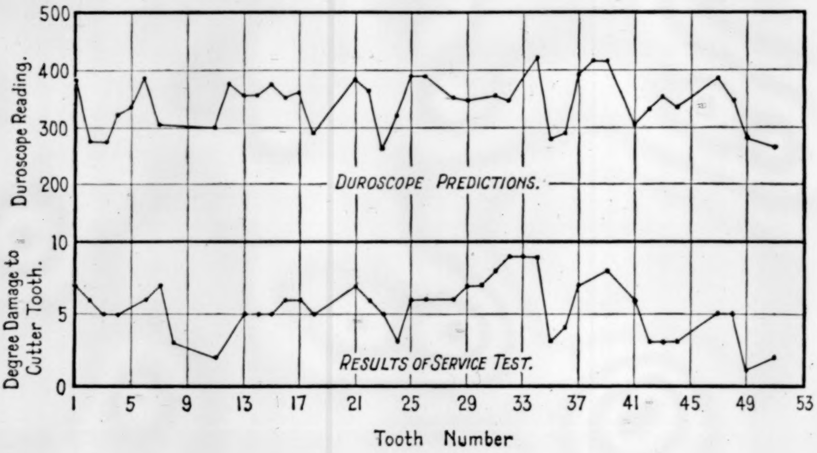


FIG. 4.—Comparison of Duroscope Predictions of Durability with Results of Service Test of High-Speed-Steel Cutter Teeth.

Damaged teeth were classified by an observer ignorant of Duroscope predictions.

The equipment for the Duroscope test consisted of the following units:

1. Power supply and rotary converter.
2. Tester, three types:
   - (*a*) Cylindrical;
   - (*b*) Cone shaped with external compensator;
   - (*c*) Pointed.
3. Compensator Box:
   - (*a*) Compensator proper for external compensation (variable transformer);
   - (*b*) Power control (rheostats);
   - (*c*) Ammeter;
   - (*d*) Control Switches.
4. Dynamometer indicator with auxiliaries such as lamp, scale, etc.

For the convenience of the operator, provision was made for keeping the testers and specimens in the same box. The apparatus with the exception of the dynamometer is shown in Fig. 2.

Test Procedure.—The Duroscope was calibrated by means of a series of specimens on which Brinell, Rockwell and scleroscope or service tests had been made. The instrument scale may also be calibrated in terms of the heat treat-

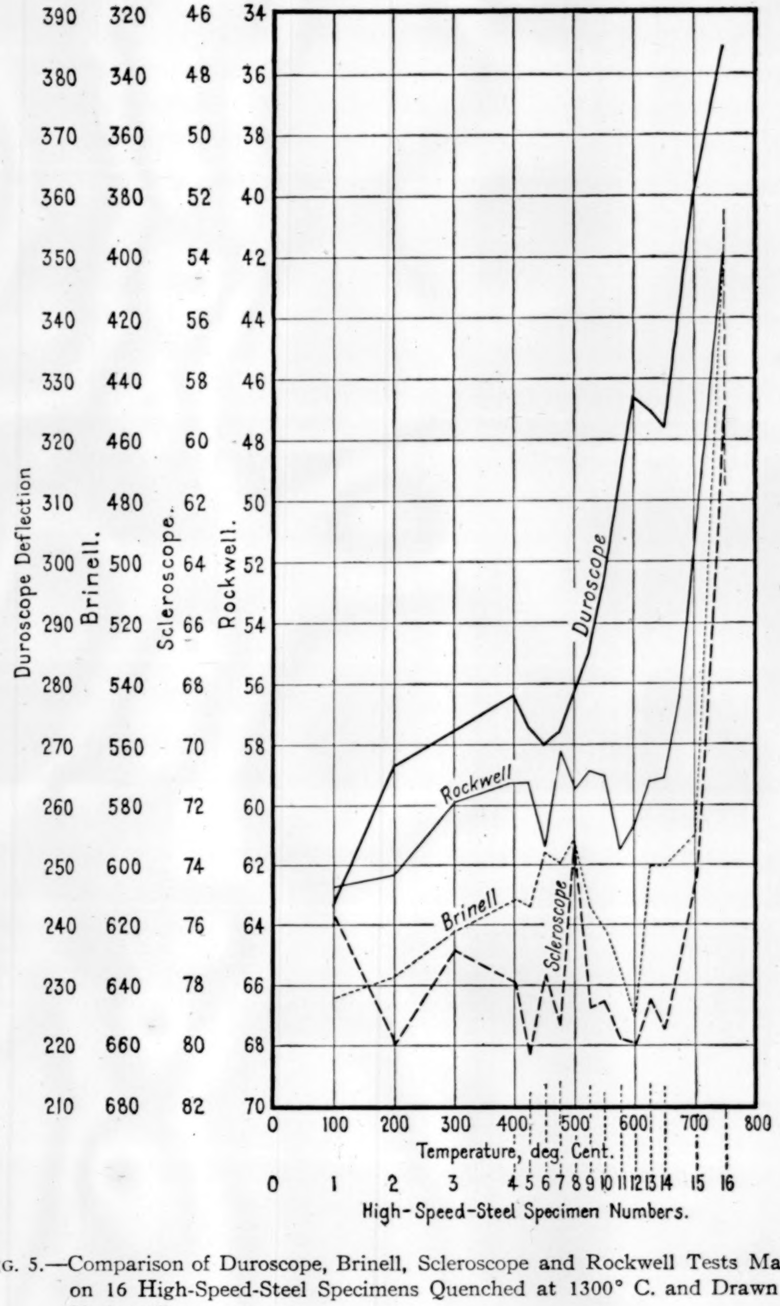
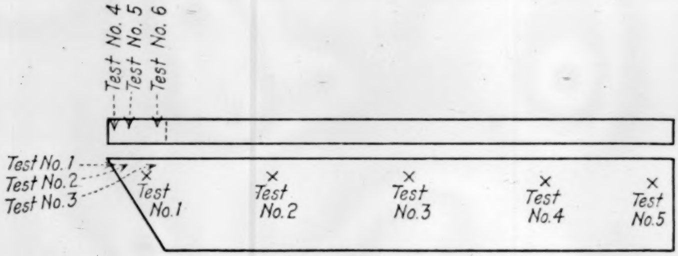


FIG. 5.—Comparison of Duroscope, Brinell, Scleroscope and Rockwell Tests Made on 16 High-Speed-Steel Specimens Quenched at 1300° C. and Drawn at Various Temperatures.

ment, grain size, or chemical composition of the specimen depending on the information wanted concerning the specimen. An illustration is given in Fig. 5, showing the Duroscope reading for various temperings as compared with the Brinell, Rockwell and scleroscope tests. It is therefore possible to calibrate the instrument scale for the variable factors upon which the durability of the tool depends, and to determine the durability at one reading, as the result of the interdependence of the various properties.

Several experimental test procedures have been adapted which are based on the drawing temperature, Brinell, Rockwell and scleroscope values of these standard specimens. This procedure consists of comparing the test specimen with the standard specimen by proportional deflection, or by calibration of the compensator scale. The test procedure will depend on the test condition and should be varied accordingly.



Arrows indicate points where Duroscope readings were made, Crosses Rockwell readings

FIG. 6.—Showing Points on Tool at Which Readings Were Taken.

TABLE I.—RESULTS OF TESTS ON HIGH-SPEED STEEL.

Specimen	Drawn at		Brinell Reading	Rockwell Reading	Scleroscope Reading	Duroscope Reading
	deg Fahr.	deg. Cent.				
No. 1	210	100	642	62.7	75.68	243
No. 2	390	200	637	62.3	80.	266.5
No. 3	570	300	622	59.9	76.87	272
No. 4	750	400	612	59.3	77.87	278
No 5	795	425	614	59.3	80.37	272.5
No. 6	840	450	595	51.4	77.62	270
No. 7	885	475	608	58.2	79.25	272
No. 8	930	500	591	59.5	73.25	278
No. 9	975	525	615	58.9	78.75	285
No. 10	1020	550	622	59.5	78.56	297
No. 11	1065	575	635	61.5	79.75	312.5
No. 12	1110	600	631	60.7	80.	327
No. 13	1155	625	608	59.2	78.50	325
No. 14	1200	650	601	59.1	79.43	322
No. 15	1290	700	590	56.6	74.62	360
No. 16	1380	750	400	41.9	53.87	385

Standard Samples.—With the use of testers *H* and *B* it is necessary for the test specimen to have a plane and finished surface. For tester *C* this is not necessary as it is designed for all conditions of surface.

For purpose of calibration a number of samples have been carefully prepared and preserved. These consist of high-speed steel pieces quenched at 1300° C. and drawn at various temperatures. The results of Brinell, Rockwell, scleroscope and Duroscope tests on these specimens are as follows:

Comparative tests have been made on various cutters to determine the uniformity of the teeth with respect to each other. The results of these tests will be given in a subsequent report when service tests of these cutters have been completed.

Results are presented in Table II of tests carried out by Mr. Dipper of the S. K. F. Industries. The only great difference in deflection obtained was on tools Nos. 13, 14, 15, 17, 18, 19 and 20, especially No. 18 which gave a negative value at the cutting edge.

Conclusions:

The object of this investigation was to develop a method and construct an apparatus which would replace or at least supplement the present methods of testing tools and cutters for durability or serviceability and which would be superior in speed, consistency and adaptability.

TABLE II.—RESULTS OF TESTS SUBMITTED BY THE S. K. F. INDUSTRIES ON 20 HIGH-SPEED CUT-OFF TOOLS.

Specimen	Quenching Temperature		Duroscope Reading[a]						Rockwell Reading[a]				
	deg. Fahr.	deg. Cent.	Test No. 1	Test No. 2	Test No. 3	Test No. 4	Test No. 5	Test No. 6	Test No. 1	Test No. 2	Test No. 3	Test No. 4	Test No. 5
No. 1....	2100	1150	80	125	165	85	110	160	60.0	60.0	60.0	59.8	59.2
No. 2....	2100	1150	90	130	170	82	145	170	59.5	59.2	58.5	58.4	57.8
No. 3....	2100	1150	65	110	160	53	85	125	60.0	59.8	59.0	59.0	58.2
No. 4....	2100	1150	65	110	150	60	100	130	60.7	60.5	59.5	60.0	59.7
No. 5....	2200	1205	65	100	145	60	100	133	62.2	62.0	61.0	61.2	60.0
No. 6....	2200	1205	65	115	160	65	90	130	62.0	61.8	61.7	61.5	61.5
No. 7....	2200	1205	55	90	120	45	80	115	62.2	62.0	61.8	60.8	61.0
No. 8....	2200	1205	60	95	135	40	74	115	61.5	62.0	61.5	62.0	61.0
No. 9....	2300	1260	70	100	155	65	90	130	64.5	64.3	64.1	64.3	63.5
No. 10...	2300	1260	90	125	155	80	115	145	64.0	63.7	63.8	63.5	63.4
No. 11...	2300	1260	60	105	145	75	110	135	64.4	64.3	63.3	64.0	63.5
No. 12...	2300	1260	90	120	170	60	100	125	63.8	63.0	63.0	62.5	63.5
No. 13...	2400	1315	30	70	110	25	65	90	65.0	64.5	64.5	64.7	64.4
No. 14...	2400	1315	15	55	110	10	45	60	65.0	64.8	64.0	65.3	64.5
No. 15...	2400	1315	25	70	110	20	50	85	64.8	64.2	64.2	65.2	64.0
No. 16...	2400	1315	80	110	160	80	100	150	64.3	64.3	64.0	64.2	64.2
No. 17...	2500	1370	5	50	100	0	40	80	65.4	65.4	65.2	65.0	65.2
No. 18...	2500	1370	−40	20	65	−30	10	55	61.5	61.0	62.0	63.5	64.3
No. 19...	2500	1370	25	65	115	10	65	110	65.3	65.0	64.5	64.8	64.3
No. 20...	2500	1370	55	85	140	46	75	115	65.0	65.0	65.1	64.8	64.8

[a] The points at which the readings were taken are shown in Fig. 6, a diagrammatic sketch of one of the tools.

As a result of this investigation and development, the Duroscope has been built. The present apparatus is so designed as to be independent of the usual variation in voltage and frequency as experienced in shop practice.

The instrument is easy to operate, convenient to use and is especially adapted to shop testing. Comparison of Duroscope, Brinell, Rockwell and scleroscope tests are shown in Fig. 5. This curve indicates the possibilities of the apparatus by its straight line characteristics, over the working range, of drawing temperatures.

The data of the tests given graphically in Fig. 5 show that the readings of the Duroscope indicate in a general way the relative durability of the teeth, but that more service tests are required to determine whether or not cutters of satisfactory durability may be definitely selected by the Duroscope test.

DISCUSSION

A Member. A MEMBER.—I should like to ask Mr. de Forest to what extent the method he has described can be applied commercially; that is, on what sizes, etc. It seems as though we have here a method for commercial application for non-destructive testing that has quite a future.

Mr. de Forest. MR. A. V. DE FOREST.[1]—That seems to be a large order. I do not know at all in what direction this method is likely to go most rapidly. At present in my own work we are dealing with small pieces of material, most of them under heat-treated conditions, and in that case we get along very nicely with apparatus as described, using sixty-cycle current. Mr. Spooner has extended that field by showing that at the lower frequencies, larger sizes can be handled just as easily. Whether that means rails, forgings, billets, ingots and anything else, I do not know. It may well be possible to go to almost any dimensions with the proper frequency and the proper method of magnetizing and the proper method of measuring magnetization. So far my work has been entirely with pieces that were easily handled in solenoid magnetizing coils.

I think there is the possibility of looking at a synthesis of all the various properties rather than picking out a single group of characteristics such as are reflected in a hardness test or a tension test with its accompanying measurements of elongation. The magnetic picture brings in both the question of internal stress, which is definitely related to the fatigue properties, and the question of grain size, which is related to impact value, so we might expect from this method to get at the major mechanical structural properties of the stock we handle.

Mr. Harris. MR. W. J. HARRIS.[2]—Could this method of inspection be applied to coil springs, such as motor valve springs?

Mr. de Forest. MR. DE FOREST.—That I think is a very simple problem. I have been handling that grade of material for some time and find it one of the easiest. Heat-treated products of small diameter are very simple indeed.

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[1] Research Engineer, American Chain Co., Inc., Bridgeport, Conn.

[2] Studebaker Corporation, Reference Department, South Bend, Ind.

Mr. White. MR. J. A. WHITE.[1]—I should like to ask what is the present status of this committee's work on high-speed drills. I notice in one of the latest reports it has been somewhat set aside in order to go into the more fundamental work on these bars.

Mr. Sanford. MR. R. L. SANFORD[2] (*Chairman, Committee A-8*).—Perhaps I can answer that question. The committee started this investigation of drills with the idea in view that in order to obtain the maximum return for the effort expended, we should attempt an application to something for which some very definite use could be found; and so the twist drill was taken as representing a fairly simple problem. As the work progressed, it was realized more and more by members of the committee, that neither high-speed steel nor twist drills were particularly simple propositions, and it seemed advisable to set the drill problem aside temporarily, and to put our efforts for a time into work on the material itself.

In that connection I might amplify a little what Mr. de Forest has just hinted at, that if the magnetic tests resulted in a single value something like Brinell hardness or tensile strength or electrical resistivity, the subject would have been exhausted a long time ago. It is because of the very complexity of the reactions of steel to magnetic forces that we have hoped to find that various properties, or various structures, will affect various magnetic properties in different ways, so that if we can untangle the picture and interpret the results, we can learn a great deal about steel. Mr. de Forest's method, it seems to me, is an exceedingly ingenious method of demonstrating at one time, in one picture, a great many things at once, which are useful in the judging of the characteristics of the material under examination. The drill problem will probably be revived when it appears that the time is ripe to work at it effectively and efficiently.

Mr. Masters. MR. F. M. MASTERS.[3]—I had the pleasure of spending a day with Mr. de Forest in his laboratories some time ago, and I have since been looking into the magnetic testing methods. I should like to ask him if he thinks it is going to be possible at any time to set standards or write standard methods of magnetic testing that can be commercially applied. Can you say that if a certain picture comes within certain lines, the piece of material being tested is good for the commercial use for which it was designed, and whether or not it should be accepted? I think that this is going to be a big problem for the Society to take up some day if this method of testing is de-

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[1] Chemist and Metallurgist, Clark Equipment Co., Buchanan, Mich.

[2] Chief, Magnetic Section, U. S. Bureau of Standards, Washington, D. C.

[3] Consulting Engineer, Harrisburg, Pa.

Mr. Masters. veloped. Standards must be fixed by which we can reject or accept the material. Mr. de Forest has probably had experience which enables him to say whether definite limits can be determined by which we can accept or reject a piece.

Mr. de Forest. MR. DE FOREST.—I had hardly looked forward to such a step in the near future; it is too complicated a subject to be able to introduce it very much in that respect into raw material. In the finished, heat-treated piece, there would be some hope of such an idea; but in the raw material, which is likely to be changed by forging and by cold working and by heat treatment, the grain structure entirely upset several times, I do not see that it is at all probable at this time.

Mr. Sanford. MR. SANFORD.—I should like to say a little bit more along the line of the last question. It seems to me—I am speaking personally now—that the most important part of this work is the fundamental part, because if the magnetic properties of materials are functions of crystal structure, that is, the arrangement of the atoms within the material, and if the mechanical properties are functions of this same arrangement, it seems to me not at all unreasonable to expect that there must be very definite laws of correlation between the two sets of properties. I know of no more difficult field of research than this, and for that reason I heartily agree with Mr. de Forest that the final answer may be a long time coming, but it will not be so long a time if those who are interested and equipped to do so, will undertake to go at the problem, not primarily from the standpoint of practical application, but in an endeavor to discover what, if any, fundamental relationships there are between these two sets of properties, because only as we understand these fundamental relationships, can we ever expect to set up standards and say that certain magnetic properties go with certain mechanical properties, or to set up standards for acceptance or rejection. It does not appear, at the present state of our knowledge, at all unreasonable to expect that ultimately this may be done.

REPORT OF COMMITTEE A-9

ON

FERRO-ALLOYS

During the past year, the committee has held one meeting at which were presented reports covering the work of the Sub-Committees on Specifications, Methods of Analysis and Methods of Sampling.

The question of the effect of tin and arsenic in high-speed steels, was deemed of sufficient importance that on the recommendation of Committee A-9 a special research committee has been appointed by the Society to carry on the investigation of the subject.

It is recommended by Committee A-9 that the following tentative specifications and methods be advanced to standard:

Tentative Specifications for Tungsten Powder (A 97 – 25 T);[1]
Tentative Specifications for Spiegeleisen (A 98 – 25 T);[1]
Tentative Specifications for Ferro-Mangnese (A 99 – 25 T);[1]
Tentative Specifications for Ferro-Silicon (A 100 – 25 T);[1]
Tentative Specifications for Ferro-Chromium (A 101 – 25 T);[1]
Tentative Specifications for Ferro-Vanadium (A 102 – 25 T);[1]
Tentative Methods of Sampling Ferro-Alloys (A 103 – 25 T);[1]
Tentative Methods of Chemical Analysis of Ferro-Alloys (A 104 – 25 T).[1]

These tentative standards have stood without revision or change for two years and investigation seems to disclose that they are satisfactory both to the manufacturers and the consumers.

In 1925, when the specifications were presented to the Society for publication as tentative, there was evoked discussion on the floor relative to the desirability for uniformity in the size of spiegeleisen and relative to the disintegration of ferro-silicon. Therefore, the tentative specifications for ferro-silicon and spiegeleisen were accepted by the Society with the understanding that these two matters would be dealt with and, if necessary, the specifications revised. The committee took up both of these subjects and decided that in regard to the uniformity of size of spiegeleisen, at the present time it would not be wise to include the proposed scheme of limiting the percentage of over and under-size lumps as it would tend to render the standard non-commercial. In regard to disintegration of ferro-silicon, it was admitted by all the manufacturers that this trouble had been encountered but it was stated it had been practically overcome and it seemed unnecessary to expand any further the clause in the specifications which reads:

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 25, Part I, pp. 528–533, 537–567 (1925); also 1926 Book of A.S.T.M. Tentative Standards, pp. 94–99, 125–155.

> "Ferro-silicon when furnished in lump or granulated form shall be free from excessive disintegration."

In considering the specifications for ferro-alloys and methods of analysis and sampling, special consideration has been given to the coordination of the requirements of both the consumer and the manufacturer. The first codification of these standards was made by the Ordnance Department, U. S. A., and subsequently approved and adopted by the Federal Specifications Board. This work was taken as a foundation for the committee's specifications. It will be noted that for the most part the committee's specifications are identical with those of the Federal Board, the only changes being better to define the product. The specifications are brief, but, in conjunction with the methods of analysis and sampling, it seems that they are sufficiently broad to furnish an adequate basis of agreement between consumer and manufacturer in the majority of cases.

The effort of the committee is now being concentrated on an expansion of the standards to include other materials used in both the ferrous and the non-ferrous metal industries as alloying materials. It is planned to include materials such as molybdenum salts which, while not strictly ferro-alloys, are replacing ferro-alloys in the trade and accomplish the same end.

There have been no changes in the personnel of the committee.

The advancement to standard of the tentative specifications and methods has been referred to letter ballot of the committee with the following results:

Items	Affirmative	Negative	Not Voting
TENTATIVE STANDARDS ADVANCED TO STANDARD			
Tentative Specifications for Tungsten Powder (A 97 - 25 T)	19	0	6
Tentative Specifications for Spiegeleisen (A 98 - 25 T)	20	0	5
Tentative Specifications for Ferro-Manganese (A 99 - 25 T)	19	0	6
Tentative Specifications for Ferro-Silicon (A 100 - 25 T)	19	0	6
Tentative Specifications for Ferro-Chromium (A 101 - 25 T)	18	0	7
Tentative Specifications for Ferro-Vanadium (A 102 - 25 T)	20	0	5
Tentative Methods of Sampling Ferro-Alloys (A 103 - 25 T)	17	0	8
Tentative Methods of Chemical Analysis of Ferro-Alloys (A 104 - 25 T)	19	0	6

This report has been submitted to letter ballot of the committee, which consists of 25 members, of whom 18 have voted affirmatively, none negatively, and 7 have refrained from voting.

Respectfully submitted on behalf of the committee,

F. C. LANGENBERG,
Chairman.

CHARLES MCKNIGHT,
Secretary.

EDITORIAL NOTE

The following tentative specifications and methods were approved at the annual meeting and subsequently adopted by letter ballot of the Society on September 1, 1927: for Tungsten Powder; for Spiegeleisen; for Ferro-Manganese; for Ferro-Silicon; for Ferro-Chromium; for Ferro-Vanadium; Methods of Sampling Ferro-Alloys; and Methods of Chemical Analysis of Ferro-Alloys. The specifications and methods appear in the 1927 Book of A.S.T.M. Standards, Part I.

REPORT OF COMMITTEE B-1
ON
COPPER WIRE

In the last annual report of Committee B-1 it was stated that there had been additions to the membership of the committee so as to qualify it as a Sectional Committee under the rules of procedure of the American Engineering Standards Committee for the consideration of specifications for hard-drawn and for medium-hard-drawn copper wire corresponding to A.S.T.M. Specifications B 1 – 23 and B 2 – 15. Since then the A.E.S.C. has also assigned sponsorship to the Society for specifications for soft annealed copper wire (B 3 – 15) and for tinned soft copper wire (B 33 – 21). The same personnel now comprising the Sectional Committee was offered to the A.E.S.C. for approval to cover these two specifications. This approval has been given in the case of specifications for soft annealed copper wire and it is still pending in the case of specifications for tinned soft copper wire. It is hoped that the approval will have been granted by the time this report is presented. Committee B-1, therefore, is now functioning both as the standing committee of the Society on copper wire in general, and as the sectional committee on the four specifications mentioned.

In 1926, tentative revisions were offered[1] in four of the standard specifications of the Society to bring them into exact agreement with the statement of the International Copper Standard covering the matter of unit weight. Further consideration has been given to these revisions and by vote of the committee they are now being offered to the Society for adoption as standard together with all other revisions submitted as tentative last year. The specifications in question are mentioned below.

With the revision of the Specifications for Round and Grooved Hard-Drawn Copper Trolley Wire (B 47 – 25) the specifications become identical with those of the American Electric Railway Association with which association the specifications have been developed cooperatively. It may confidently be expected that these specifications will become the standard of the country for copper trolley wire.

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 26, Part I, p. 161 (1926).

Cooperative work with the A.E.R.A. on the Specifications for Bronze Trolley Wire (B 9 – 26 T) has resulted in a revision of the specifications covering the matter of tensile strength and number of twists. The proposed revisions reported by the Conference Committee have been accepted by Committee B-1, which committee recommends that the specifications be amended accordingly and be continued as tentative. These same revisions will be recommended to the A.E.R.A. by their representatives who will urge adoption.

There are now on Committee B-1, functioning as the sectional committee, representatives of the large power-producing and transmitting industries and of the communication industries which together are the large users of hard-drawn and medium-hard-drawn wire and cable made from such wire. The specifications for these products are undergoing very careful review by the committee and it may be hoped that within another year specifications may be offered which will be satisfactory to all of the interests involved.

In 1926, the Tentative Specifications for Soft Rectangular Copper Wire (B 48 – 26 T)[1] were amended to cover the matter of unit weight as previously mentioned. These specifications are now offered for approval as standard without further revision.

TENTATIVE REVISIONS OF EXISTING STANDARDS ADVANCED TO STANDARD

The standard specifications of which revisions were proposed in 1926, which revisions are now recommended for adoption as standard as given in the 1926 report of the committee,[2] are the following:

Standard Specifications for Hard-Drawn Copper Wire (B 1 – 23);[3]

Standard Specifications for Medium Hard-Drawn Copper Wire (B 2 – 15);[3]

Standard Specifications for Soft or Annealed Copper Wire (B 3 – 15);[3]

Standard Specifications for Bare Concentric-Lay Copper Cable: Hard, Medium-Hard, or Soft (B 8 – 21);[3]

Standard Specifications for Round and Grooved Hard-Drawn Copper Trolley Wire (B 47 – 25).[4]

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 26, Part I, p. 687 (1926); also 1926 Book of A.S.T.M. Tentative Standards, p. 173.

[2] *Proceedings*, Am. Soc. Testing Mats., Vol. 26, Part I, p. 161 (1926).

[3] 1924 Book of A.S.T.M. Standards.

[4] A.S.T.M. Standards Adopted in 1925.

TENTATIVE SPECIFICATIONS ADVANCED TO STANDARD

The Tentative Specifications for Soft Rectangular Copper Wire (B 48 - 26 T)[1] are recommended for advancement to standard.

TENTATIVE SPECIFICATIONS REVISED AND CONTINUED AS TENTATIVE

The following revisions are recommended in the Tentative Specifications for Bronze Trolley Wire (B 9 - 26 T),[2] the specifications to be continued as tentative:

Table I.—Change to read as follows by the addition of the italicized figures and the omission of those in brackets:

TABLE I.—VALUES FOR TENSILE STRENGTH AND ELONGATION OF ROUND WIRE.

		HIGH-STRENGTH BRONZE WIRE		MEDIUM-STRENGTH BRONZE WIRE	
DIAMETER, IN.	AREA, CIRCULAR MILS.	TENSILE STRENGTH, LB. PER SQ. IN.	ELONGATION IN 10 IN., PER CENT	TENSILE STRENGTH, LB. PER SQ. IN.	ELONGATION IN 10 IN., PER CENT
0.548	300 000	[70 000] *66 000*	4.50	[60 000] *59 000*	4.50
0.460	211 600	[73 000] *69 000*	3.75	[62 000] *61 000*	3.75
0.410	168 100	[76 000] *71 000*	3.25	[64 000] *63 000*	3.25
0.365	133 225	[79 000] *73 000*	[2.80] *2.75*	[66 000] *65 000*	[2.80] *2.75*
0.325	105 625	[81 000] *76 000*	2.40	[69 000] *68 000*	2.40

Section 4.—Change the last sentence from its present form: namely,

"Wire shall not be considered satisfactory which does not withstand at least twenty turns before breaking."

to read as follows:

"Wire shall not be considered satisfactory which does not withstand, before breaking, at least the number of turns specified below:

DIAMETER	NUMBER OF TWISTS
0.548	20
0.460	23
0.410	25
0.365	27
0.325	30"

Section 6 (a).—Change from its present form: namely,

"The physical tests for grooved wire shall be made in the same manner as those upon the round wire. The tensile strength of grooved wire shall be at least 95 per cent of that required for round wire of the same nominal cross-sectional area; the elongation shall be the same as that required for round wire of the same nominal cross-sectional area. The twist test shall be omitted."

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 26, Part I, p. 687 (1926); also 1926 Book of A.S.T.M. Tentative Standards, p. 173.

[2] *Proceedings*, Am. Soc. Testing Mats., Vol. 26, Part I, p. 682 (1926); also 1926 Book of A.S.T.M. Tentative Standards, p. 168.

to read as follows:

> "The physical tests for grooved wire shall be made in the same manner as those upon round wire. The tensile strength and elongation shall not be less than the values given in Table II. The twist test shall be omitted.

TABLE II.—VALUES FOR TENSILE STRENGTH AND ELONGATION OF GROOVED WIRE.

	HIGH-STRENGTH BRONZE WIRE		MEDIUM-STRENGTH BRONZE WIRE	
AREA, CIRCULAR MILS.	TENSILE STRENGTH, LB. PER SQ. IN.	ELONGATION IN 10 IN., PER CENT	TENSILE STRENGTH, LB. PER SQ. IN.	ELONGATION IN 10 IN., PER CENT
300 000........	66 000	4.00	59 000	4.00
211 600........	69 000	3.25	61 000	3.25
168 100........	71 000	2.75	63 000	2.75
133 225........	73 000	2.25	65 000	2.25
105 625........	76 000	2.00	68 000	2.00

WITHDRAWAL OF STANDARD SPECIFICATIONS

The Standard Specifications for High-Strength Bronze Trolley Wire, Round and Grooved: 40 and 65-per-cent Conductivity (B 9 - 16)[1] are recommended to be withdrawn.

All of the recommendations appearing in this report have been referred to letter ballot of the committee with the following results:

Items	Affirmative	Negative	Not Voting
I. TENTATIVE REVISIONS OF SPECIFICATIONS ADVANCED TO STANDARD			
1. For Hard-Drawn Copper Wire (B 1 - 23)........	17	0	1
2. For Medium Hard-Drawn Copper Wire (B 2 - 15)........	17	0	1
3. For Soft or Annealed Copper Wire (B 3 - 15)........	17	0	1
4. For Bare Concentric-Lay Copper Cable: Hard, Medium-Hard, or Soft (B 8 - 21)....	16	0	2
5. For Round and Grooved Hard-Drawn Copper Trolley Wire (B 47 - 25)........	16	0	2
II. TENTATIVE SPECIFICATIONS ADVANCED TO STANDARD			
6. For Soft Rectangular Copper Wire (B 48 - 26 T)........	16	0	2
III. TENTATIVE SPECIFICATIONS REVISED AND CONTINUED AS TENTATIVE			
7. For Bronze Trolley Wire (B 9 - 26 T)........	16	0	2
IV. WITHDRAWAL OF STANDARD SPECIFICATIONS			
8. For High-Strength Bronze Trolley Wire, Round and Grooved: 40 and 65-per-cent Conductivity........	17	0	1

This report has been submitted to letter ballot of the committee, which consists of 18 members, all of whom have voted affirmatively.

Respectfully submitted on behalf of the committee,

J. A. CAPP,
Chairman.

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[1] 1924 Book of A.S.T.M. Standards.

EDITORIAL NOTE

The tentative revisions of the Standard Specifications for Hard-Drawn Copper Wire; for Medium-Hard-Drawn Copper Wire; for Soft or Annealed Copper; for Bare Concentric-Lay Copper Cable: Hard, Medium-Hard, or Soft; and for Round and Grooved Hard-Drawn Copper Trolley Wire, were approved at the annual meeting and subsequently adopted by letter ballot of the Society on September 1, 1927. The specifications as revised appear in the 1927 Book of A.S.T.M. Standards, Part I.

The Tentative Specifications for Soft Rectangular Copper Wire were approved at the annual meeting and subsequently adopted by letter ballot of the Society on September 1, 1927. They appear in the 1927 Book of A.S.T.M. Standards, Part I.

The proposed revisions of the Tentative Specifications for Bronze Trolley Wire were accepted. The specifications as revised appear on page 709.

The Standard Specifications for High-Strength Bronze Trolley Wire, Round and Grooved: 40 and 65-per-cent Conductivity, were withdrawn.

REPORT OF COMMITTEE B-2
ON
NON-FERROUS METALS AND ALLOYS

During the past year, Committee B-2 has held two meetings, one at Detroit, September, 1926, and one at Philadelphia, March, 1927. It has developed six new proposed tentative standards, it proposes revisions of three present standards and of one tentative standard, and recommends the advancement to standard of six tentative standards, and of six revisions of standards.

The recommendations of the committee relative to standards and tentative standards are as follows:

I. Tentative Standards Advanced to Standard.—The committee recommends that the following tentative specifications be advanced to standard without revision:

1. Tentative Specifications for Muntz Metal Condenser Tube Plates (B 57 – 25 T);[1]
2. Tentative Specifications for Manganese-Bronze Ingots for Sand Castings (B 7 – 24 T);[2]
3. Tentative Specifications for Manganese-Bronze Sand Castings (B 54 – 24 T);[2]
4. Tentative Specifications for Phosphor Tin (B 51 – 24 T);[2]
5. Tentative Specifications for Phosphor Copper (B 52 – 24 T);[3]
6. Tentative Specifications for Silicon Copper (B 53 – 24 T).[2]

II. Tentative Revisions of Standards Advanced to Standard.—The committee recommends that the revisions of the following standards, which were submitted by the committee in 1925 and 1926, be adopted as published in the Proceedings of the Society for 1926,[3] and that the standards be revised accordingly.

7. Standard Specifications for Lake Copper Wire Bars, Cakes, Slabs, Billets, Ingots, and Ingot Bars (B 4 – 13);

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 25, Part I, p. 583 (1925); also 1926 Book of A.S.T.M. Tentative Standards, p. 204.

[2] *Proceedings*, Am. Soc. Testing Mats., Vol. 24, Part I, pp. 779–784, 789–793 (1924); also 1926 Book of A.S.T.M. Tentative Standards, pp. 162–167, 183–187.

[3] *Proceedings*, Am. Soc. Testing Mats., Vol. 26, Part I, pp. 1113 ff. (1926).

8. Standard Specifications for Electrolytic Copper Wire Bars, Cakes, Slabs, Billets, Ingots, and Ingot Bars (B 5 - 13);
9. Standard Specifications for Naval Brass Rods for Structural Purposes (B 21 - 19), revised as indicated in the Appendix to this report;
10. Standard Specifications for High Sheet Brass (B 36 - 21);
11. Standard Methods of Chemical Analysis of Brass Ingots and Sand Castings (B 45 - 23);
12. Standard Methods of Chemical Analysis of Bronze Bearing Metal (B 46 - 23).

III. Proposed New Tentative Standards.—The committee submits for publication as tentative the following six new specifications as appended hereto:[1]

13. Proposed Tentative Specifications for Copper Tubing for Refrigerators;
14. Proposed Tentative Specifications for Brazing Solder;
15. Proposed Tentative Specifications for Yellow Brass Sand Castings for General Purposes;
16. Proposed Tentative Specifications for Bronze Castings in the Rough for Locomotive Wearing Parts;
17. Proposed Tentative Specifications for Car and Tender Journal Bearings, Lined;
18. Proposed Tentative Specifications for Rolled Zinc.

The proposed Tentative Specifications for Bronze Castings in the Rough for Locomotive Bearing Parts and the proposed Tentative Specifications for Car and Tender Journal Bearings, Lined, are intended to replace the present Tentative Specifications for Non-Ferrous Alloys for Railway Equipment in Ingots, Castings, and Finished Car and Tender Bearings (B 17 - 21 T).[2]

IV. Proposed Revisions of Standards.—The committee recommends that the revisions of the following specifications be accepted for publication as tentative, as given in the appendix to this report.

19. Standard Specifications for Cartridge Brass (B 19 - 19);[3]
20. Standard Specifications for Cartridge Brass Disks (B 20 - 19).[3]

V. Proposed Revisions of Tentative Standard.—The committee recommends that the proposed revisions of the following tentative methods be approved, as given in the appendix to this report, and that the methods, as revised, be continued as tentative.

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[1] See pp. 706 and 714–736.—ED.

[2] *Proceedings*, Am. Soc. Testing Mats., Vol. 21, p. 486 (1921); also 1926 Book of A.S.T.M. Tentative Standards, p. 206.

[3] 1924 Book of A.S.T.M. Standards.

21. Tentative Methods of Chemical Analysis of Aluminum and Light Aluminum Alloys (B 40 - 26 T).[1]

VI. Withdrawal of Standard.—The committee recommends that the following standard be withdrawn, since the present Tentative Specifications for Aluminum-Base Sand-Casting Alloys in Ingot Form (B 58 - 26 T) and the Tentative Specifications for Aluminum Base Alloy Sand Castings (B 26 - 26 T) are intended to supersede this standard:

22. Standard Specifications for Light Aluminum Casting Alloys (B 26 - 21).[2]

VII. Correction in Standard.—The committee recommends that the following standard specifications be corrected as indicated in the appendix to this report:

23. Standard Specifications for Copper Pipe, Standard Sizes (B 42 - 24).[2]

VIII. Tentative Specifications Continued as Tentative.—The following specifications are recommended for continuance as tentative, without revision:

Tentative Specifications for Aluminum Bronze Castings (B 59 - 26 T);
Tentative Specifications for Sand Castings of the Alloy: Copper 88 per cent; Tin 8 per cent; Zinc 4 per cent (B 60 - 26 T);
Tentative Specifications for Steam or Valve Bronze Sand Castings (B 61 - 26 T);
Tentative Specifications for Composition Brass or Ounce Metal Sand Castings (B 62 - 26 T);
Tentative Specifications for Aluminum Ingots for Remelting (B 24 - 26 T);
Tentative Specifications for Aluminum Sheet (B 25 - 26 T);
Tentative Specifications for Aluminum Base Alloy Sand Castings (B 26 - 26 T);
Tentative Specifications for Aluminum-Base Sand-Casting Alloys in Ingot Form (B 58 - 26 T).

It is further recommended that the present tentative revisions of the Standard Specifications for Seamless Admiralty Condenser Tubes and Ferrule Stock (B 44 - 24) be continued as tentative.

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 26, Part I, p. 718 (1926); also 1926 Book of A.S.T.M. Tentative Standards, p. 219.

[2] 1924 Book of A.S.T.M. Standards.

ACTIVITIES OF SUB-COMMITTEES

Sub-Committee I on Pure Metals in Ingot Form (W. H. Bassett, chairman).—This sub-committee is now actively engaged in drawing up proposed specifications for fire-refined copper and expects to be able to present these to the Society in 1928.

Sub-Committee II on Wrought Metals and Alloys (W. Reuben Webster, chairman).—Further work is being done to develop a proper set of diametral tolerances for condenser tubes (Standard Specifications B 44 – 24) as well as to reconcile the details of testing condenser tubes in compression with the specified practice of the American Marine Standards. The sub-committee has prepared new tentative specifications for copper tubing for refrigerators and for brazing solder, which specifications are recommended for publication as tentative. It has further recommended the advancement to standard of the present Tentative Specifications for Muntz Metal Condenser Tube Plates (B 57 – 25 T).

Sub-Committee III on Sand-Cast Metals and Alloys (N. K. B. Patch, chairman).—Sub-Committee III is this year recommending for publication as tentative new specifications for yellow brass sand castings. It is recommending the advancement to standard of the present Tentative Specifications for Manganese-Bronze Ingots for Sand Castings (B 7 – 24 T) and the Tentative Specifications for Manganese-Bronze Sand Castings (B 54 – 24 T). The sub-committee proposes to revise in 1928 the present Standard Specifications for Brass Ingot Metal, Graded and Ungraded, for Sand Castings (B 30 – 22) and the Standard Specifications for Bronze Bearing Metal in Ingot Form (B 31 – 21).

Sub-Committee IV on White Metals (G. H. Clamer, chairman).—The two research programs started last year on wear and on fluidity of white metal bearing alloys have had to be deferred until arrangements can be made for cooperating laboratories to undertake the work.

Sub-Committee VI on Non-Ferrous Alloys for Railroad Equipment (G. H. Clamer, chairman).—The present Tentative Specifications for Non-Ferrous Alloys for Railway Equipment in Ingots, Castings, and Finished Car and Tender Bearings (B 17 – 21 T)[1] are being replaced by two new specifications (the proposed Tentative Specifications for Bronze Castings in the Rough the for Locomotive Bearing Parts, and proposed Tentative Specifications for Lined Journal Bearings) which are in harmony with those of the American Railway Association, although not in identical form. It is felt that the new specifications will be used to a considerable extent by the railroads.

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 21, p. 486 (1921); also 1926 Book of A.S.T.M. Tentative Standards, p. 206.

Sub-Committee VII on Methods of Chemical Analysis (W. A. Cowan, chairman).—This sub-committee has extensively revised the present Tentative Methods of Chemical Analysis of Aluminum and Light Aluminum Alloys (B 40 – 26 T). It plans to take up during the coming year the consideration of methods of chemical analysis of silver solders, specifications for which are being developed by Sub-Committee XIV.

Sub-Committee VIII on Light Metals and Alloys (E. Blough, chairman).—In addition to the current work on standards, two interesting investigations are under way. One section is studying the problem of testing sand castings and will probably be prepared to report in 1928.

Another section is undertaking an investigation of the testing of aluminum die-castings which will comprise hardness, tensile and impact tests of some 70,000 castings. This section will be enlarged and made a separate sub-committee of Committee B-2 to deal with die-castings generally, including tin, lead and zinc-base alloys.

Sub-Committee XII on Metallic Fluxes and Deoxidizers (P. E. McKinney, chairman).—This sub-committee is engaged in developing specifications for manganese alloys for use in non-ferrous metals.

In addition it hopes within the next year or two to present a comprehensive report on the general subject of "deoxidizing" and "fluxing" non-ferrous metals, giving a statement of practice usually followed with the different commercial alloys.

The present Tentative Specifications for Phosphor Tin (B 51 – 24 T), for Phosphor Copper (B 52 – 24 T) and for Silicon Copper (B 53 – 24 T) are being recommended for advancement to standard on the recommendation of the sub-committee.

Sub-Committee XIII on Rolled Zinc (G. C. Stone, chairman).—This sub-committee is submitting new specifications for rolled zinc. The methods and equipment described in the proposed specifications, for ductility testing of zinc, will prove of considerable interest to those interested in testing metals.

Sub-Committee XIV on Silver and Gold Solders (R. H. Leach, chairman).—This sub-committee has been but recently organized and is at work on the development of specifications for silver solders.

The recommendations appearing in this report have been submitted to letter ballot of the committee, with the following results:

Items	Affirmative	Negative	Not Voting
I. TENTATIVE STANDARDS ADVANCED TO STANDARD			
1. Tentative Specifications for Muntz Metal Condenser Tube Plates (B 57 - 25 T)	35	0	84
2. Tentative Specifications for Manganese-Bronze Ingots for Sand Castings (B 7 - 24 T)	39	0	80
3. Tentative Specifications for Manganese-Bronze Sand Castings (B 54 - 24 T)	38	0	81
4. Tentative Specifications for Phosphor Tin (B 51 - 24 T)	41	0	78
5. Tentative Specifications for Phosphor Copper (B 52 - 24 T)	41	0	78
6. Tentative Specifications for Silicon Copper (B 53 - 24 T)	40	0	79
II. TENTATIVE REVISIONS OF STANDARDS ADVANCED TO STANDARD			
7. Standard Specifications for Lake Copper Wire Bars, Cakes, Slabs, Billets, Ingots, and Ingot Bars (B 4 - 13)	43	1	75
8. Standard Specifications for Electrolytic Copper Wire Bars, Cakes, Slabs, Billets, Ingots, and Ingot Bars (B 5 - 13)	45	1	73
9. Standard Specifications for Naval Brass Rods for Structural Purposes (B 21 - 19)	38	2	79
10. Standard Specifications for High Sheet Brass (B 36 - 21)	39	0	80
11. Standard Methods of Chemical Analysis of Brass Ingots and Sand Castings (B 45 - 23)	40	0	79
12. Standard Methods of Chemical Analysis of Bronze Bearing Metal (B 46 - 23)	40	0	79
III. PROPOSED NEW TENTATIVE STANDARDS			
13. Proposed Tentative Specifications for Copper Tubing for Refrigerators	33	0	86
14. Proposed Tentative Specifications for Brazing Solder	38	0	81
15. Proposed Tentative Specifications for Yellow Brass Sand Castings	38	0	81
16. Proposed Tentative Specifications for Bronze Castings in the Rough for Locomotive Wearing Parts	35	0	84
17. Proposed Tentative Specifications for Lined Journal Bearings	32	0	87
18. Proposed Tentative Specifications for Rolled Zinc	33	1	85
IV. PROPOSED REVISIONS OF STANDARDS			
19. Standard Specifications for Cartridge Brass (B 19 - 19)	31	0	88
20. Standard Specifications for Cartridge Brass Disks (B 20 - 19)	30	0	89
V. PROPOSED REVISION OF TENTATIVE STANDARD			
21. Tentative Methods of Chemical Analysis of Aluminum and Light Aluminum Alloys (B 40 - 26 T)	38	0	81
VI. WITHDRAWAL OF STANDARD			
22. Standard Specifications for Light Aluminum Casting Alloys (B 26 - 21)	38	1	80

This report has been submitted to letter ballot of the committee, which consists of 119 members, of whom 52 have voted affirmatively, none negatively, and 67 have refrained from voting.

Respectfully submitted on behalf of the committee,

W. H. BASSETT,
Vice-Chairman.

PAUL D. MERICA,
Secretary.

EDITORIAL NOTE

The tentative revisions of the Standard Specifications for Naval Brass Rods for Structural Purposes, amended as recommended by the committee, were approved at the annual meeting and subsequently adopted by letter ballot of the Society. The specifications as revised appear in the 1927 Book of A.S.T.M. Standards, Part I.

The tentative revisions of the Standard Specifications for Lake Copper Wire Bars, Cakes, Slabs, Billets, Ingots, and Ingot Bars; for Electrolytic Copper Wire Bars, Cakes, Slabs, Billets, Ingots, and Ingot Bars; for High

Sheet Brass; and of the Methods of Chemical Analysis of Brass Ingots and Sand Castings; and of Chemical Analysis of Bronze Bearing Metal, were approved at the annual meeting and subsequently adopted by letter ballot of the Society on September 1, 1927. The specifications and methods as revised appear in the 1927 Book of A.S.T.M. Standards, Part I.

The following tentative specifications were approved at the annual meeting and subsequently adopted by letter ballot of the Society on September 1, 1927: for Muntz Metal Condenser Tube Plates; for Manganese-Bronze Ingots for Sand Castings; for Manganese-Bronze Sand Castings; for Phosphor Tin; for Phosphor Copper; and for Silicon Copper. The specifications appear in the 1927 Book of A.S.T.M. Standards, Part I.

The proposed revisions of the Standard Specifications for Cartridge Brass; and for Cartridge Brass Disks, were accepted for publication as tentative and appear on page 1092.

The proposed Tentative Specifications for Bronze Castings in the Rough for Locomotive Wearing Parts; and for Journal Bearings, Lined, were accepted for publication as tentative to replace the Tentative Specifications for Non-Ferrous Alloys for Railway Equipment in Ingots, Castings, and Finished Car and Tender Bearings. The new specifications appear on pages 718 and 721, respectively. The proposed Tentative Specifications for Copper Tubing for Refrigerators; for Brazing Solder; for Yellow Brass Sand Castings for General Purposes; and for Rolled Zinc, were accepted for publication as tentative and appear on pages 725, 706, 714 and 727, respectively.

The proposed revisions of the Tentative Methods of Chemical Analysis of Aluminum and Light Aluminum Alloys were accepted. The methods as revised appear on page 740.

The Standard Specifications for Light Aluminum Casting Alloys were withdrawn.

APPENDIX

PROPOSED REVISIONS OF STANDARDS AND TENTATIVE STANDARDS FOR NON-FERROUS METALS AND ALLOYS

Below are given in detail the revisions proposed in standards and tentative standards. The item numbers correspond to the numbers used in the report of the committee.

PROPOSED REVISIONS IN STANDARDS

No. 9. *Standard Specifications for Naval Brass Rods for Structural Purposes (B 21 - 19).*[1]—

Section 3.—Change the requirement for copper from "59.00–62.00 per cent" to "59.0–61.0 per cent," and the requirement for tin from "0.50–1.50 per cent" to "0.5–1.0 per cent."

Section 5.—Omit this section reading as follows:

> "(*a*) Analyses of separate rods may be made by the purchaser. The copper content thus determined shall lie within the following limits:
>
> Copper.. 59–63 per cent.
>
> "(*b*) In case of dissatisfaction, the rod or rods shall be sampled in the presence of representatives of both parties. The thoroughly mixed sample shall be divided into three equal parts, each of which shall be placed in a sealed package, one for each party and one for an umpire, if necessary."

Section 6.—Add a Paragraph (*b*) to read as follows:[2]

> "(*b*) Yield point in tension shall be determined as the stress producing an elongation under load of 0.5 per cent, that is, 0.01 in. in a gage length of 2 in."

No. 19. *Standard Specifications for Cartridge Brass (B 19 - 19).*[1]—

Section 4.—Change the requirement for copper from "66.5–69.5 per cent" to "68.0–71.0 per cent."

Section 6.—Omit Paragraph (*a*) reading as follows, making Paragraph (*b*) appear as Section 6:

> "Analyses of separate pieces may be made by the purchaser. The copper, lead, and iron contents thus determined shall be as follows:

Copper..............................		66.0–70.0 per cent
Lead..................................	not over	0.10 "
Iron....................................	" "	0.08 "

Section 7.—Change the Brinell hardness limits from "51 to 65" to read "49 to 65." Omit the last sentence, reading as follows

> "No individual test shall exceed the limits of 50 to 69."

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[1] 1924 Book of A.S.T.M. Standards.

[2] This revision was submitted as tentative in 1925.

Add a note to this section, to read as follows:

"NOTE.—Thesee spcifications are intended to cover the requirements of commercial practice which do not in all cases agree with those of the Ordnance Department. These departures involve only the degree of final annealing."

No. 20. *Standard Specifications for Cartridge Brass Disks* (*B 20 - 19*).[1]—

Section 3.—In Paragraph (*a*) change the gage tolerances to read as follows by the addition of the italicized figures and the omission of those in brackets:

Gage	Permissible Variation, in.
Up to 0.150 in., incl	[±0.0025] *−0, +0.0050*
Over 0.150 to 0.300 in., incl	[±0.003] *−0, +0.006*
Over 0.300 to 0.400 in., incl	[±0.004] *−0, +0.008*
Over 0.400 in	[±0.005] *−0, +0.010*

Add a new heading and a new section, to read as follows:

PHYSICAL PROPERTIES AND TESTS

4. The brass shall be so annealed that the average of ten Brinell hardness readings from a lot will be within the limits of 49 to 65, using a 10-mm. ball and a pressure of 500 kg.

NOTE.—These specifications are intended to cover the requirements of commercial practice which do not in all cases agree with those of the Ordnance Department. These departures involve only the degree of final annealing.

No. 23. *Standard Specifications for Copper Pipe, Standard Sizes* (*B 42 - 24*).[1]—

As a correction in Section 5 of these specifications, insert the word "minimum" between the words "following" and "requirements."

PROPOSED REVISIONS OF TENTATIVE STANDARDS

No. 21. *Tentative Methods of Chemical Analysis of Aluminum and Light Aluminum Alloys* (*B 40 - 26* T).[2]—The following revisions are recommended in the methods covering the analysis of aluminum (not less than 98 per cent). All page references refer to Volume 26, Part I, of the Proceedings of the Society.

On page 719, under "Notes" add an additional note (the third note) to read as follows:

"Since there may be a slight loss of silicon in the filtrates from the silica filtrations, this amount should be recovered by repeated evaporations of the filtrates, for accurate work."

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[1] 1924 Book of A.S.T.M. Standards.

[2] *Proceedings*, Am. Soc. Testing Mats., Vol. 26, Part I, p. 718 (1926); also 1926 Book of A.S.T.M. Tentative Standards, p. 219.

On page 721, under "Method" change the first two sentences to read as follows:

> "Dissolve 1 g. of the well-mixed sample in 35 cc. of the acid mixture and proceed as in "Determination of Total Silicon" until the first insoluble residue is ignited. Treat this with a little concentrated HNO_3 and HF to remove the silicon, then evaporate to dryness. Fuse the unvolatilized part with $K_2S_2O_7$, dissolve in a little H_2SO_4 (5-per-cent) and add to the main solution."

On page 723, under "Notes" add another note (the fifth) to read as follows:

> "If the electrolytically deposited copper is not bright in appearance, it should be dissolved from the cathode and redeposited from a sulfuric-nitric acid solution, the operation being carried through in the same way as in the first electrolysis."

On page 724, under "Notes," in the second line of the third, and last, note delete "NaCl."

On page 724, under "(*b*) *Bismuthate Method*," under "Solutions Required" delete the first direction for mixing "Dilute Sulfuric Acid (1: 1)" and in place of this insert the following direction:

> "'*Acid Mixture.*'—Pour 400 cc. of H_2SO_4 (sp. gr. 1.84) into distilled water, cool and add 400 cc. of HNO_3 (sp. gr. 1.42). Then dilute the mixture with distilled water to a total volume of 2000 cc."

On page 724, at the bottom of the page under "Method" under "(*b*) *Bismuthate Method*" change the first sentence describing manner of solution to read as follows:

> "In a 250-cc. Erlenmeyer flask, dissolve 1 g. of the sample in 30 cc. of acid mixture by warming on a water bath until solution is complete."

The methods covering the analysis of light aluminum alloys appearing on pages 725 to 737, Volume 26, Part I of the Proceedings of the Society, have been completely rewritten and are appended hereto in their proposed revised form.[1]

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[1] The revised methods have been incorporated in the Tentative Methods of Chemical Analysis of Aluminum and Light Aluminum Alloys and appear on pages 748 to 756.—ED.

REPORT OF COMMITTEE B-3

ON

CORROSION OF NON-FERROUS METALS AND ALLOYS

Since submitting its last report, Committee B-3 has been active in completing the laboratory tests previously started, in summarizing the results of these tests, in laying out the procedure for further laboratory tests, in organizing additional sub-committees and in planning the future programs for these new sub-committees.

TOTAL-IMMERSION TESTS

The results obtained in the first series of tests do not show satisfactory agreement among various cooperating laboratories. When the results are compared on the basis of the order in which the metals are rated, 1, 2, 3, etc., the agreement is somewhat better.

The method of aeration employed in these tests is entirely inadequate, owing to lack of suitable control. This is indicated by the very poor agreement, even among duplicate specimens.

While the average results of different laboratories did not agree, still the duplicate results of any one laboratory showed on the whole good agreement, indicating the necessity for more exact specifications for the control of important factors. The degree of aeration is of vital importance and has not been controlled sufficiently closely in these tests.

It has been decided that a second and less extensive series of tests be carried out, and that the procedure be modified so that more consistent results will be obtained.

Total-Immersion Tests, Modified Procedure:

1. The following metal-solution combinations are suggested:

$NaCl$:	H_2SO_4:	$NaOH$:
Aluminum	Aluminum	Admiralty
Admiralty	Admiralty	Copper
Copper	Copper	Lead
Lead	Lead	Nickel
Nickel	Nickel	Zinc
Zinc		

2. It will not be necessary to grind the specimen flat. They should be simply cleaned by rubbing with No. 00 French emery paper, washing in water and alcohol.

3. Use c. p. chemicals from common stock.
4. Specimens should be cleaned chemically wherever possible.
5. Use three specimens instead of four for each test.
6. Non-aerated tests carried out in bottles as before. The specimen should be placed in the bottles and *not disturbed* until the end of the test to avoid all unnecessary aeration.
7. *Aerated tests.*—Use apparatus similar to that described by McKay in *Chemical and Metallurgical Engineering.*
8. For these tests determine only loss in weight.
9. The following durations of tests should be used:

Non-Aerated:

NaCl	30 days
H_2SO_4	3 "
NaOH	3 "

Aerated:

NaCl	30 days
H_2SO_4	3 "
NaOH	3 "

10. Carry out tests at a temperature of 60° C.

Future Total-Immersion Tests:

The following have agreed to cooperate in the carrying out of future tests in accordance with the modified procedure shown above:

W. M. Corse for the Duriron Co.,
D. K. Crampton for the Chase Metal Works,
F. H. Williams for the Canadian National Railways,
L. F. Pratt for the National Canners Association (non-aerated tests),
H. A. Bedworth for the American Brass Co.

Besides the above, W. H. Finkeldey, of the New Jersey Zinc Co., has agreed to look into the matter of a chemical method for cleaning zinc and E. H. Dix, Jr., of the Aluminum Co. of America, has agreed to do the same for aluminum.

Specimens for a majority of the work outlined above are available and active testing will begin at once.

ALTERNATE-IMMERSION TESTS

The first series of alternate-immersion corrosion tests was run by the following laboratories:

Aluminum Co. of America
American Brass Co.

Bureau of Standards
Chase Metal Works
Lunkenheimer Co.
National Lead Co.
New Jersey Zinc Co.

The results of the tests from all these laboratories have been reported.

A study of the results of the first series of tests shows that the test is far from satisfactory in its present form. The most outstanding thing about the results obtained was the lack of agreement between the various laboratories. In most cases the greatest rate reported by any laboratory was from 5 to 10 times as great as the lowest rate reported by any laboratory. In very few instances was this ratio as low as 1.5 to 1. It would seem that, before the test could be recommended as a standard method of procedure, checks between different laboratories should show rates not greater than approximately 1.5 to 1.

In general, the continuous alternate-immersion test gave distinctly more uniform, as well as greater, corrosion rates than did the interrupted alternate immersion test. In view of this, the committee has decided to work only with the continuous alternate-immersion test, at least for the immediate future. It is felt that, although the past results were disappointing in so far as uniformity is concerned, the test apparatus and procedure can be so modified that concordant results can be obtained with different laboratories and the test therefore become a useful one for studying the behavior of various metal-solution combinations.

Alternate-Immersion Test, Modified Procedure:

The modifications which appear necessary to bring the test into a satisfactory state are as follows:

1. An accurate control of temperature is highly essential. The directions for operating the test originally specified temperature control, but this point was not actually adhered to by all laboratories, and unquestionably accounts for a certain amount of the discrepancies noted.

2. In general, a very much longer time of test is necessary in order that the actual metal loss will be large enough to give reliable results. In a great many instances in the past series, the weight loss was less than the experimental errors.

3. Control of the rate of drying of the samples after leaving the solution appears to be highly important. In the past series there was no control of this feature and the temperature and humidity of

the air over the apparatus gave rise to great variations. It was apparent that the samples should either be positively dry in as short a time as possible or else kept positively moist for the entire part of the cycle in which they were suspended in the air; any condition in between would obviously lead to great experimental errors. It was decided to adopt, for the present, the policy of using a higher temperature of solution, thereby resulting in the almost immediate and complete drying of the samples.

4. The volatility of the solute in certain cases appeared to be a large, if not a controlling, factor. This is especially true with ammonium hydroxide and to a less extent with acetic acid and hydrochloric acid. Where the solute is non-volatile, it is proper to maintain the original level of the solutions in the beakers by the addition of distilled water. Where the solute is volatile the only safe procedure is to completely renew the entire solution every 24 hours. The importance of this of course increases with the volatility of the solute.

5. The method of preparation of samples originally proposed appears altogether too arduous and adds nothing to the value of the test. It appears that all that is necessary is to prepare a surface by rubbing with No. 00 French emery and washing in alcohol and ether. It is not necessary to grind the sample flat as originally proposed.

6. The methods of cleaning the samples after the test appear satisfactory in the case of some metals but unsatisfactory in the case of aluminum and zinc. Before a standard procedure can be recommended, it will be necessary to obtain further data on the suitability of various methods of cleaning these metals.

7. It is felt that a greater volume of solution per sample would be helpful and it is recommended that 350 cc. of solution per beaker instead of 250 cc. be used.

8. It is necessary to accurately control the exact time in the cycle at which the samples enter and leave the solution. All samples should enter and leave the solution at precisely the same point in the cycle. This can be achieved in various ways, but one simple, satisfactory way is as follows:

> Three hundred and fifty cubic centimeters of solution should be put in all the beakers and the samples suspended so as to enter as nearly as possible at the same time and at approximately one-half the distance from the top to the bottom of the stroke. Thereafter they should be run until the first sample just touches the solution and then stopped. Further solution can be added to the other beakers until all samples just touch at this point. The beakers can be marked to show the initial correct starting level and thereafter brought to this point daily, or as often as necessary.

9. Control of the laboratory atmosphere is essential. The tests

should properly be run in a separate room where fumes from the various other tests or analysis will not interfere.

10. The use of criteria other than loss of weight will obviously be necessary in the future. Although loss of weight only will be used in the next series of tests, it is felt that rate of penetration by pitting, change in various physical properties such as strength and ductility, and possibly other criteria will ultimately be found more valuable, at least in certain cases.

Future Alternate-Immersion Tests:

A new modified series of tests will be run carrying out the changes which appear to be necessary. This new series will be run with the continuous alternate-immersion test only, on the following metal-solution combinations:

Normal Sodium Chloride.—30 days at 60° C. ± 1° C.:

Aluminum,
Admiralty Metal,
Copper,
Lead,
Nickel,
Zinc.

Normal Sulfuric Acid.—3 days at 60° C. ± 1° C.:

Aluminum,
Admiralty Metal,
Copper,
Lead,
Nickel.

Normal Sodium Hydroxide.—3 days at 60° C. ± 1° C.:

Admiralty Metal,
Copper,
Lead,
Nickel,
Zinc.

It is the feeling of the committee that on this new series of tests, with the modified procedure, concordant results can be obtained by the various laboratories. If this proves true the committee will be in a position to recommend a definite procedure for a standard test.

The following laboratories have signified their intention of running the new modified series of tests:

American Brass Co.,
Canadian National Railways,
Chase Metal Works,
National Lead Co.

SPRAY CORROSION TEST

A comparison of the results obtained in the spray corrosion tests will not warrant any definite conclusion being drawn as to why the results of different cooperators do not agree more closely. There is good reason to believe that, in the spray test, the solutions as used are completely aerated, hence the differences in test results cannot be attributed to different degrees of aeration as may be the case for some other test methods. The factor which, from abstract consideration, would appear most probable is the amount of solution reaching and condensing upon the surface of the specimens. If this were the controlling factor, however, it would be expected that the results obtained by one laboratory would, in the great majority of cases, always bear the same relation to the results obtained by another laboratory, that is, be either greater or less. The average results for the different cooperators, however, do not substantiate this assumption. Two laboratories may show very good agreement for a series of tests in one solution and differ very widely for other series.

In the case of metals which show a tendency in certain solutions to form an adherent corrosion deposit, some of the differences may, in all probability, be attributed to this factor, which may be accentuated by the method used in freeing the surface of the metal from the adherent corrosion product. Further suggestions as to why the results differ so widely would be almost entirely speculative in character and might bear no relation whatever to the available test results.

The results obtained in the Committee B-3 series of tests indicate quite clearly on the whole, however, that with the present technique, the applicability of the spray test is limited and the method offers little promise as a general means for determining the corrosion-resistance of metals. The results of tests now in progress in the sub-committee, in which various forms of apparatus are being used and all tests are being conducted by the same operator, may, however, when available permit more definite conclusions as to the factors which must be controlled if consistent and reproducible test results are to be obtained.

Spray Test, Modified Procedure:

A very excellent plan prepared by Mr. R. M. Curts of the New Jersey Zinc Co., Palmerton, Pa., for a tentative standard spray test apparatus was submitted for the sub-committee's consideration.

The plan includes the following:

(*a*) 24 by 20 by 20-in. glazed stoneware tank with baffle plate;
(*b*) ¼-in. glass rods for suspension of specimens;

(*c*) ¼-in. glass tube inlet;

(*d*) 2-in. glass tube exhaust;

(*e*) Spray nozzle as adopted by the Sub-Committee on Spray Tests after making comparative performance tests of the various possible types. It is obvious that a nozzle which performs well at a low pressure would be most desirable. (Apropos the comparative performance tests, Mr. Curts has suggested that the laboratories using spray nozzles submit a sample nozzle for test. The Aluminum Co. of America and the U. S. Bureau of Standards have expressed their willingness to cooperate. The American Brass Co. has already supplied a nozzle of its type. The Naval Gun Factory has supplied a nozzle also. However, the acceptance of a standard spray apparatus need not be held up because of the present inadequate knowledge as to the performance of various types of spray nozzles.)

(*f*) Air control.—Apparatus for the purification (if necessary) and control of air supply will not be included here because such equipment would depend upon the type of spray nozzle.

(*g*) Heating device.—A hole for the entrance of heater conduits has been included in the design of the stoneware tank. At present it may be best to work with room temperatures—which program would mean considerable saving in the original cost of the apparatus. Later in the program there could be adopted a standard heating device which could be installed alike in all tanks. For the present the above-mentioned hole can be plugged with sealing wax.

After having tested the four types mentioned in the plan Mr. Curts will report his findings to the sub-committee.

ACCELERATED-ELECTROLYTIC TEST

The schedule of Sub-Committee V has been completed. Accelerated electrolytic tests have been made and reported by the Bureau of Standards, Bridgeport Brass Co., Scovill Manufacturing Co., and Union College, and the General Electric Co.

The tests were carried out according to the original procedure laid down by the committee in 1924, such procedure being in agreement with the method of R. J. Anderson as published in *Bulletin 6* of the Carnegie Institute of Technology.

The agreement of the results obtained by the various laboratories is in the opinion of the committee very good. It is also the opinion of the committee that except in very special cases, such as those where an outside e. m. f. is involved, the results do not have a direct bearing upon the corrosion rate of the metals in the various mediums used. The test will undoubtedly prove to be of great value, where leakage currents are involved and in certain investigational work.

In the accelerated electrolytic test the rate of corrosion is due primarily to two factors, namely,

1. Solubility of the metal.
2. Accelerating effect due to current.

The following conclusions have been drawn:

(*a*) The presence of factor (2) will in most cases affect conditions, thus modifying the rate of attack under factor (1).

(*b*) Factor (1) is a function of the metal itself, the corroding medium and of the area of the sample exposed.

(*c*) Factor (2) is a function of the total current and independent of current density over a large range of values.

(*d*) In the cases where factor (2) is rapid, film formation is prevented and the rate of attack under factor (1) thereby accelerated.

(*e*) Where the metal is not readily attacked by the aqueous solution, but is readily attacked by the anion with formation of a soluble salt, the rate of solution can be expected to agree with the electrochemical equivalent of the metal.

(*f*) In general, in the electrolytic test method, as outlined, metal in being removed from the specimen at a sufficiently rapid rate to prevent the formation of a protective film. Consequently, the results of this test can not be expected to agree with those of other tests where protective film formation is an important factor.

RESULTS OF LABORATORY TESTS

A method of plotting results of corrosion tests was devised by Mr. D. K. Crampton of the Chase Metal Works which was found very interesting and helpful and was adopted by the committee. Mr. M. F. Sayre of Union College, Schenectady, N. Y., used this method in preparing the charts shown as Figs. 1 to 8, inclusive. Figures 1 to 6 show graphically all of the test data obtained to date by all of the various laboratories cooperating with Committee B-3.

In these figures, the following legends apply:

Laboratory:	Symbol
Aluminum Co. of America	/
American Brass Co.	\
Bridgeport Brass Co.	△
Bureau of Standards	○
Chase Metal Co.	□
De Laval Separator Co.	⊟
Du Pont Co.	✓
General Electric Co. {Union College}	L
International Nickel Co.	●
Lunkenheimer	¬
National Canners Association	⊖
New Jersey Zinc Co.	×
Scovill Mfg. Co.	⩜
National Lead Co.	∩

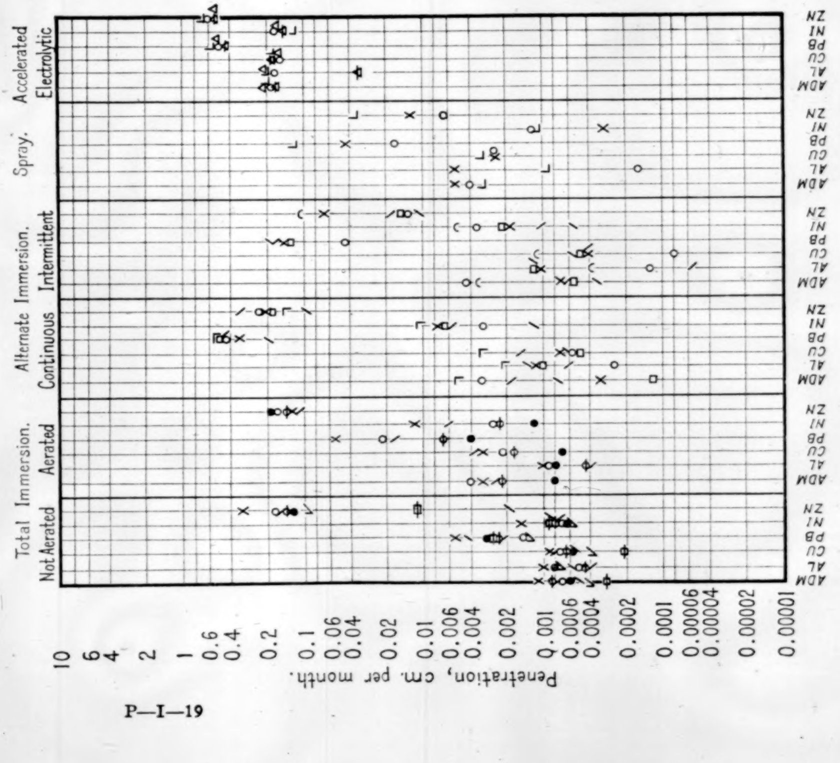

FIG. 1.—Showing Corrosion Measurements in Penetration with Sample Subjected to Acetic Acid.

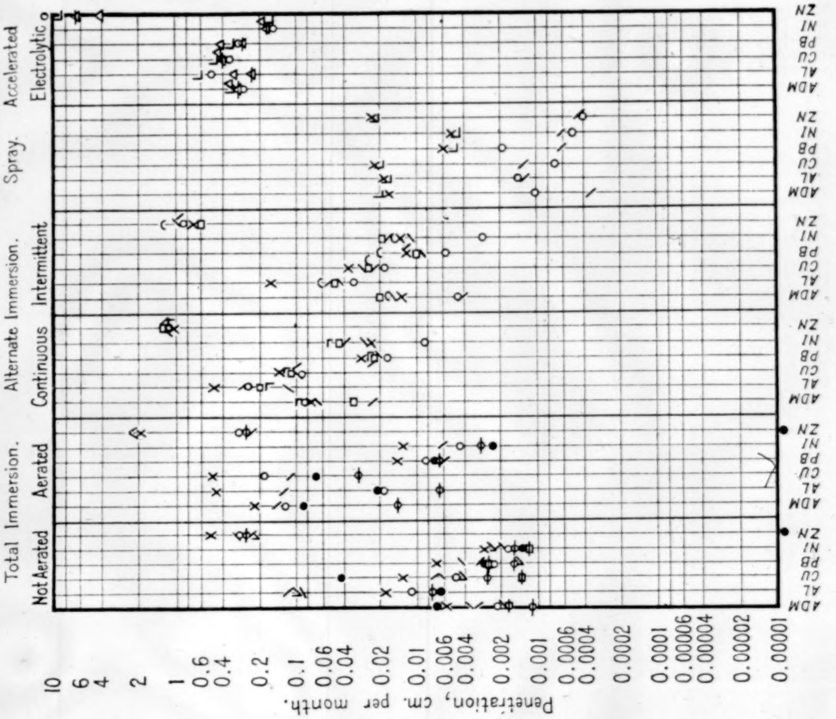

FIG. 2.—Showing Corrosion Measurements in Penetration with Sample Subjected to Hydrochloric Acid.

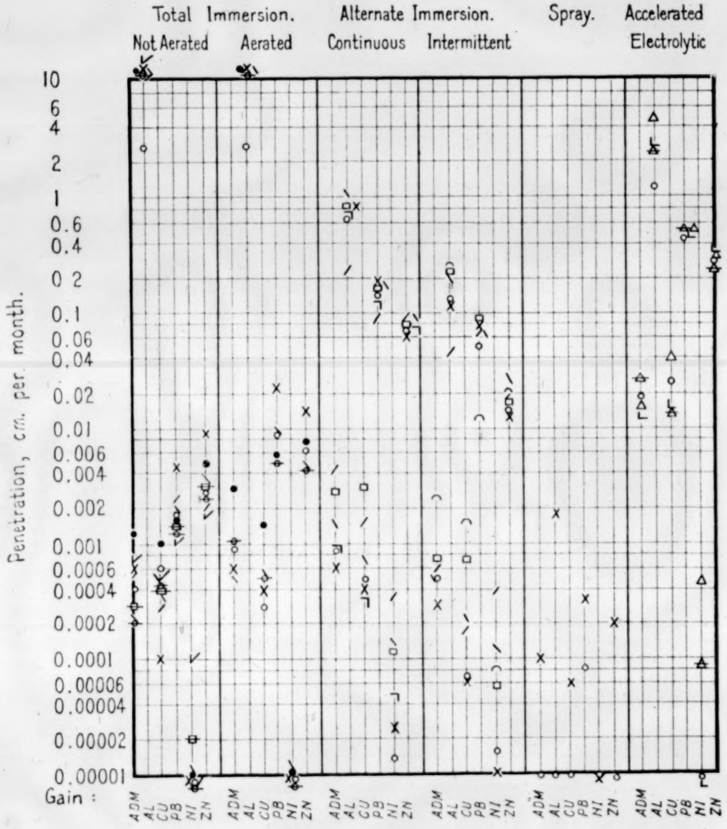

FIG. 3.—Showing Corrosion Measurements in Penetration with Sample Subjected to Sodium Hydroxide.

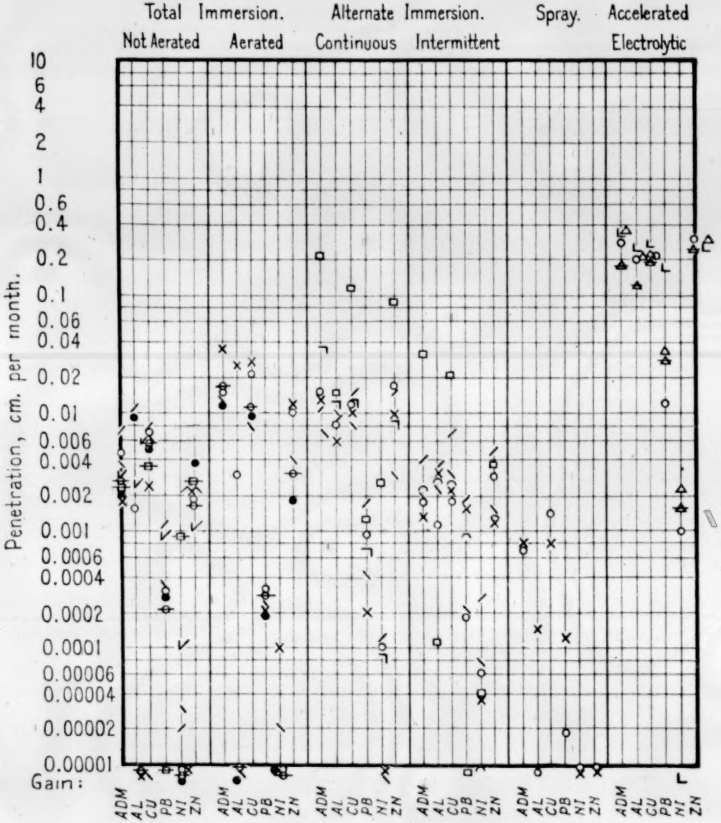

FIG. 4.—Showing Corrosion Measurements in Penetration with Sample Subjected to Ammonium Hydroxide.

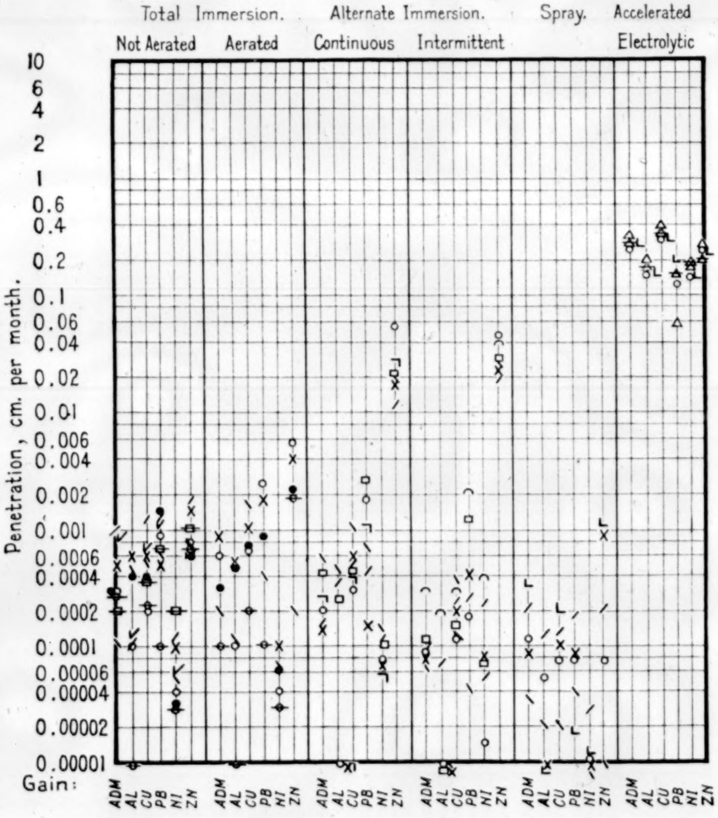

FIG. 5.—Showing Corrosion Measurements in Penetration with Sample Subjected to Sodium Chloride.

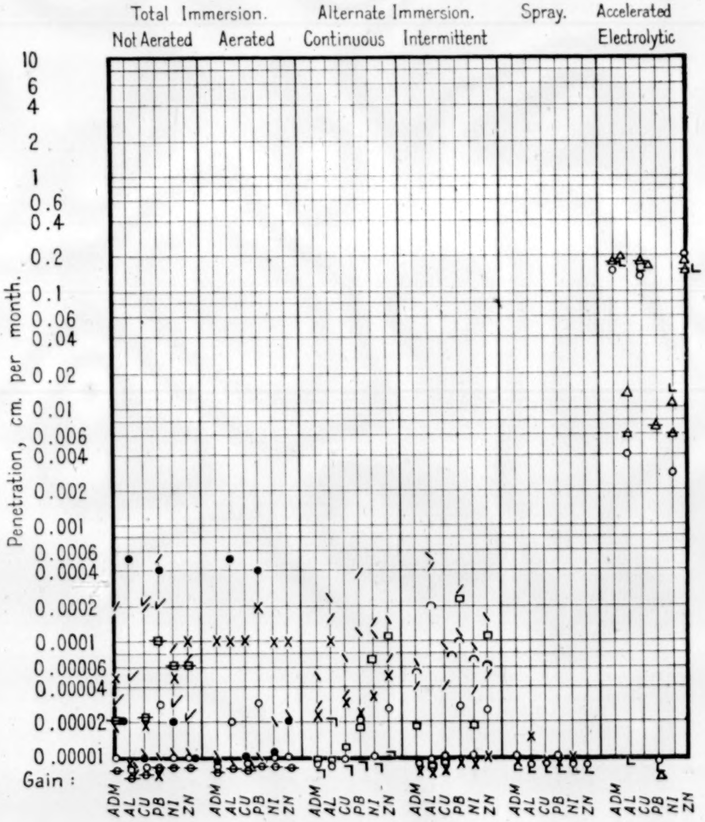

FIG. 6.—Showing Corrosion Measurements in Penetration with Sample Subjected to Potassium Bichromate.

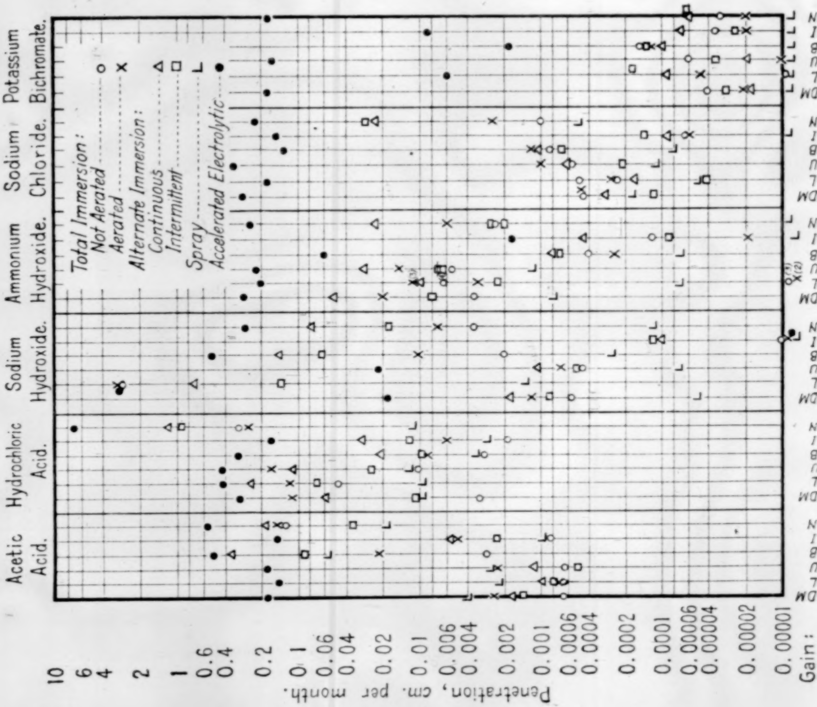

FIG. 7.—Corrosion Expressed as Penetration.

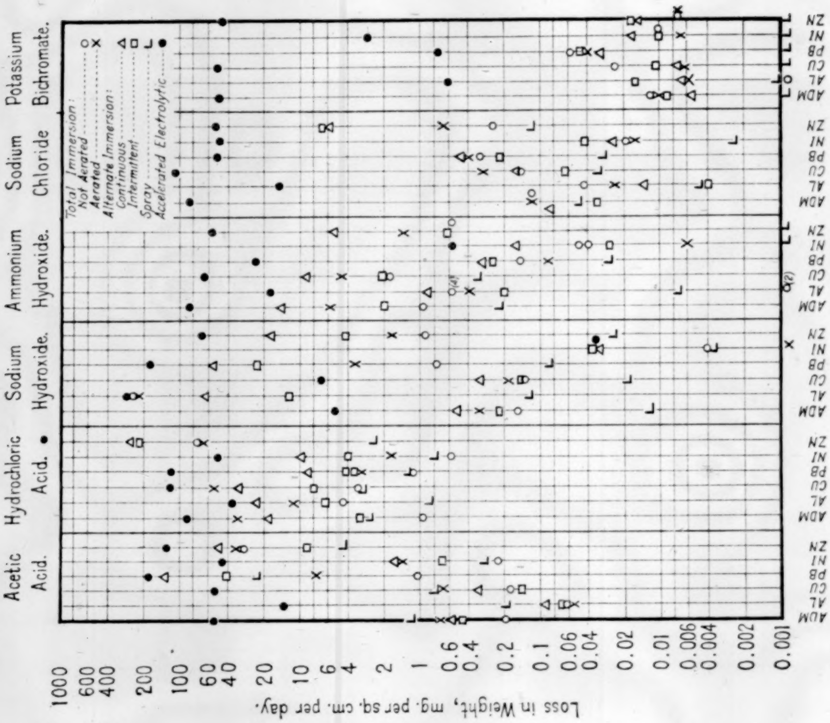

FIG. 8.—Corrosion Expressed as Loss in Weight.

The following points are very clearly brought out:

1. The relative rates of corrosion of the different metals in a given solution.

2. The relative rates of corrosion of the different types of tests for a given metal-solution combination.

3. The degree of uniformity of tests as reported by different laboratories for a given test and metal-solution combination.

Figures 7 and 8 show the average penetration and weight loss values obtained by all cooperating laboratories on each metal-solution combination in each type of test.

Atmospheric Corrosion

Sub-Committee VI, dealing with Atmospheric Corrosion, both outdoor and indoor, of non-ferrous metals and alloys, has planned to make tests on the following list of materials in the form of rolled sheet or strip, 0.035 in. thick:

Commercial copper, 99 per cent + of copper.
Brass, 85 per cent copper, 15 per cent zinc.
Brass, 70 per cent copper, 30 per cent zinc.
Admiralty metal, 70 per cent copper, 29 per cent zinc, 1 per cent tin.
Aluminum bronze, 92 per cent copper, 8 per cent aluminum.
Tin bronze, 94 per cent copper, 6 per cent tin.
Copper-nickel alloy, 75 per cent copper, 20 per cent nickel, 5 per cent zinc.
Copper-nickel alloy, 70 per cent copper, 29 per cent nickel, 1 per cent tin.
Manganese bronze.
Copper-silicon alloy, 96 per cent copper, 3 per cent silicon, 1 per cent manganese.
Commercial nickel, 99 per cent nickel.
Monel metal, 69 per cent nickel, 28 per cent copper, 2 per cent iron.
Commercial aluminum, 99 per cent + of aluminum.
Aluminum manganese alloy, 98¾ per cent aluminum, 1¼ per cent manganese.
Duralumin, 95 per cent aluminum, 4 per cent copper, 0.5 per cent manganese, 0.5 per cent magnesium.
Aluminum-magnesium-silicon alloy, 98.4 per cent, aluminum, 1 per cent silicon, 0.6 per cent magnesium.
Commercial zinc (Prime Western grade), 98 per cent + of zinc.
Commercial zinc (High Grade), 99.9 per cent zinc.
Lead-antimony alloy, approximately 99 per cent lead, 1 per cent antimony.
Commercial lead, 99 per cent + of lead.
Commercial tin, Straights tin or material of equivalent purity.

The sub-committee plans to expose two types of test specimens: panels 9 by 12 in., from which loss in weight data will be obtained; tension test specimens, which will be tested from time to time to determine the loss in breaking strength and drop in elongation, due to corrosion. In connection with the tests of the latter specimens, a duplicate set will be stored in a normal non-corrosive indoor atmosphere, and specimens from this stock tested whenever tests are made on the tension test specimens exposed in the atmosphere, in order to determine the changes in tensile properties, due to aging phenomena.

The following test locations have been selected as representative of the common types of atmosphere:

Pennsylvania State College, State College, Pa.—Rural
Altoona, Pa.—Semi-industrial
Pittsburgh, Pa.—Industrial
Sandy Hook, N. J.—Northern seacoast
Key West, Fla.—Southern Seacoast
New York City—A semi-industrial and seacoast combination.

Permission has been secured from Committee A-5 on Corrosion of Iron and Steel to locate the racks, on which the test panels will be exposed, on the same site where it has erected its own exposure racks. This includes all of the above locations except New York City.

Two types of portable test racks have been selected by the committee on which will be mounted the 9 by 12-in. test panels and the tension test specimens. This will permit these racks to be removed from the main test fence and shipped to some central location for examination, weighing and testing of the tension test specimens, whenever it is desirable to make an inspection. The large test panels will then be remounted upon the racks, and returned to the test fence for further exposure. This plan has the advantage of practically eliminating field inspections, which involve considerable time and expense on the part of the committee members.

LIQUID CORROSION

Sub-Committee VII on Liquid Corrosion has planned a number of field tests of metals against a few common solutions. In each case, the solutions, and the conditions under which the metals are tested, are to be representative of those existing in some industrial process which is in general use.

The metals included in each test will be limited to those which may reasonably be expected to prove practical for use in each process.

To distribute the work, each field test will be carried out under the supervision of a committee member who will report to the chairman. As soon as the corrosive conditions in the separate field tests are fully established, labratory experiments will be started, under the supervision of committee members, in an attempt to duplicate the actual rate of corrosion by a simple corrosion test.

In most field experiments, both Sub-Committee VII and Sub-Committee VIII on Galvanic and Electrolytic Action will cooperate in field testing, especially in view of the fact that in the construction of equipment, both liquid and electrolytic corrosion are usually involved.

The following program for field experiments has been adopted:

1. *Sodium Hydroxide.*—Tubes made of suitable metals will be installed in vacuum evaporators employed in the manufacture or recovery of caustic soda from solutions used in industry. Mr. R. P. Russell, Research Laboratory of Applied Chemistry, Massachusetts Institute of Technology, will supervise the installation and testing of these tubes. It is planned to place tubes in evaporators operating, (*a*) for the production of commercially pure caustic, and (*b*) for the recovery of caustic from "black liquor" as produced in sulfate paper mills. Possibly one or two additional tests will be arranged for.

2. *Sulfuric Acid.*—Sets of metal rods will be installed as pickling pins in racks employed in the pickling of steel. Samples of sheet, made of the same metals, will also be placed on the sides of each pickling tank where rods are being tested. It is planned to conduct field tests in a pickling plant where an inhibitor is used, and in one where no inhibitor is used. It was suggested that field tests be conducted in plants where pickling is carried out (*a*) to remove scale prior to cold rolling, (*b*) to prepare sheet steel for galvanizing, and (*c*) to prepare sheet steel for tinning. Mr. P. D. Schenck of the Duriron Co. has accepted the responsibility for supervising this field test.

3. *Hydrochloric Acid.*—Samples of rod (or flats) and sheet will be tested in pickling equipment employed for pickling with hydrochloric acid. The method of testing will be similar to that described under sulfuric acid. It was suggested that field tests be conducted in plants where pickling is carried out (*a*) to prepare steel parts for porcelain enameling, and (*b*) to prepare steel parts for galvanizing. The supervision of this test has been assigned to Mr. T. H. Addie, of the American Manganese Bronze Co.

4. *Sodium Chloride.*—Samples of sheet metals will be submerged in sea water in at least two localities. It has been suggested that this field test could be carried out in conjunction with tests being conducted by Committee A-5, at Portsmouth, N. H., and Key West, Fla. This procedure would avoid the necessity of periodic determination of the temperature, salt content, etc., of the water, as these observations are already being made by Committee A-5 in connection

with their field tests on the action of sea water on ferrous metals. Mr. W. R. Webster of the Bridgeport Brass Co. has accepted responsibility for arranging the test.

As at present planned the following materials will be included in the field tests:

1. *Sodium Hydroxide:*
    - Copper
    - Tin Bronze
    - Brass
    - Nickel
    - Admiralty Metal
    - Ambrac Metal
    - Monel Metal
    - Adnic Metal
2. *Sulfuric Acid:*
    - Copper
    - Tin Bronze
    - Brass
    - Admiralty Metal
    - Aluminum Bronze
    - Leaded Bronze
    - Lead (sheet samples only)
    - Hytensil Bronze
    - Phosphor Bronze
    - Everdur
    - Ambrac Metal
    - Monel Metal
    - Nickel
    - Adnic Metal
3. *Hydrochloric Acid:*
    - Everdur
    - Hytensil Bronze
    - Tin Brass
    - Duriron
    - Monel Metal
    - Nickel
4. *Sodium Chloride:*
    - Copper
    - Tin Bronze
    - Brass
    - Admiralty Metal
    - Leaded Bronze
    - Nickel
    - Phosphor Bronze
    - Hytensil Bronze
    - Everdur
    - Ambrac
    - Monel Metal
    - Adnic Metal

All materials used in the tests will be referred to by composition, when reporting the results of field tests.

A standard size of test specimen identical with those adopted by Sub-Committees VI and VIII and Committee A-5 will be adopted in cases where the scheme is practical. Tension test specimens will be included in the field tests whenever conditions permit.

GALVANIC AND ELECTROLYTIC ACTION

Sub-Committee VIII on Galvanic and Electrolytic Action has made the following decisions regarding its future work:

1. At the start, to confine attention to a study of galvanic effects, the term "galvanic" being used to refer to the effect of contact between dissimilar metals upon the rate of corrosion of each.

2. To carry on exposure tests in three liquid media; one of high conductivity, as a weak acid solution or a strong brine, one of medium conductivity, as sea water, one of low conductivity, as lake or reservoir water, or better, hot water in a house heating system or the hot well of a power house.

3. To cooperate with Sub-Committee VI in a study of galvanic effects under atmospheric conditions, using their test sites. For the present this work would be restricted to certain locations only, probably one to represent industrial atmospheres and one to represent salt atmospheres.

4. To use aluminum, copper, iron, lead, nickel, tin and zinc as typical metals for the purpose of these tests, these metals being chosen so as to cover a wide range of solution potentials while at the same time opening the way for combinations typical of most of the combinations of metals which are likely to be found in practice.

Sixteen combinations of these metals are to be used:

Aluminum with copper, iron, tin and zinc.
Copper with iron, lead, tin and zinc.
Lead with iron, nickel and zinc.
Nickel with iron, tin and zinc.
Tin with iron. Zinc with iron.

In addition, as controls, each metal is to be inserted as a sample by itself to give inherent rate of corrosion, and also paired with itself to show the effect of the method of clamping the samples together upon the inherent rate of corrosion.

A number of shapes of test samples and of method of clamping the test samples in pairs have been discussed. Choice has been made of one type, but this choice is tentative and the design may need to be changed after further experience. For this reason, the first set of samples will be put out in duplicate only at each site, enough for a preliminary run of relatively short duration. It is felt that it would be undesirable to start long-time exposure tests until the method of testing is better standardized than at present.

FINANCES

The tests planned for Sub-Committees VI, VII and VIII will cost a sum of money which will have to be raised by some means or other. The total cost of test racks, etc., is being estimated so that a decision can be arrived at as to how much will be required to carry out the entire program. An intensive campaign will then be necessary to obtain contributions.

This report has been submitted to letter ballot of the committee, which consists of 35 members, of whom 30 have voted affirmatively, none negatively, and 5 have refrained from voting.

Respectfully submitted on behalf of the committee,

T. S. FULLER,
Chairman.

SAM TOUR,
Secretary.

REPORT OF COMMITTEE B-4
ON
METALLIC MATERIALS FOR ELECTRICAL HEATING

Two meetings of the committee have been held during the year, as follows, in addition to the one to be held during the annual meeting of the Society: On October 18, 19, 1926, at Schenectady, N. Y.; and on February 24, 25, 1927, at Philadelphia, Pa.

Three members have been added to the committee during the year, making the present membership 15, classified as 9 non-producers and 6 producers.

A Proposed Tentative Method of Test for Change of Resistance with Temperature is appended to this report[1] and is recommended for publication as tentative. The method first investigated was not entirely satisfactory due mainly to the large thermal capacity of the form upon which the specimen was mounted. Several laboratories then made measurements, using specimens which did not require the use of a form, with satisfactory results, but it was found that the previous mechanical and thermal treatment of the specimens had an important bearing on the change of resistance with temperature.

Some elaborate experiments on this subject have been carried out by members of the committee. Typical results are shown in Fig. 1. The curves indicated by the dotted lines were obtained in one laboratory, and those with solid lines were obtained in a second laboratory. The specimens tested were nickel-chromium wire containing approximately 80 per cent of nickel and 20 per cent of chromium and were from different manufacturers. In the test represented by the solid curve, the specimen was maintained at 1000° C. for 15 hours to determine the rate of oxidation at this temperature. Additional tests of this material showed that if the specimen was cooled slowly, the curve always returned to zero.

This has been taken care of by heating the specimen to maximum temperature so as to stabilize it, and then cooling the specimen slowly. The descending curve is then taken as representing the temperature-resistance characteristics of the material.

Proposed Tentative Methods of Chemical Analysis are appended to this report[2] and are recommended for publication as tentative. These include methods of analysis for nickel, chromium, iron, manganese, carbon, silicon and insoluble residue in nickel-chromium and nickel-chromium-iron alloys. These alloys can not always be analyzed satisfactorily by the methods in common use as is evident by the wide discrepancies in results secured by different laboratories before any standardization of methods was attempted.

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[1] See p. 757.—Ed. [2] See p. 761.—Ed.

In formulating the present methods, the methods used at one laboratory were circularized among six well-known laboratories with a sample of nickel-chromium alloy and one of nickel-chromium-iron alloy. These samples were made up in the following way: Ten pounds of each alloy in the form of wire were drawn down through diamond dies to approximately 0.015 in. in diameter. This wire was then rolled to a ribbon $\frac{1}{32}$ in. wide by 0.005 in. thick. This ribbon was kept very clean during the rolling process, and was not annealed. It was then made up into a cable approximately 200 ft. long, consisting of about 60 strands. This cable was then wound on a spool and samples were obtained by cutting off several feet of the cable so

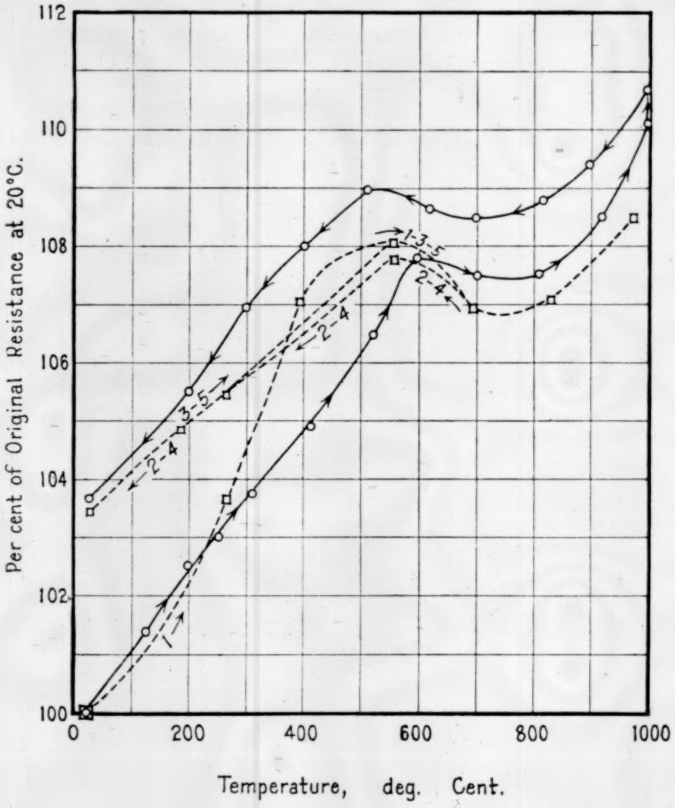

FIG. 1.—Typical Results of Tests on Change of Resistance with Temperature of Electrical Resistance Alloys.

that any one sample represented portions of the original bar of metal taken from at least 60 points in the bar.

Each laboratory was requested to analyze the samples by means of the method suggested or by any other method that it might prefer. In nearly every instance each laboratory preferred to use its own method. When the results were compared it was found that in a number of cases they were widely divergent. The determinations on a few of the elements were in close agreement and the methods for determining these elements were readily standardized. In respect to the remaining elements, additional samples were sent out and the methods employed were modified in the light of criticisms received until at the end the results from all six laboratories showed very good agreement as indicated in the following table:

ANALYSIS OF NICKEL-CHROMIUM SAMPLES

LABORATORY	NICKEL, PER CENT	CHROMIUM, PER CENT	MANGANESE, PER CENT	IRON, PER CENT	SILICON, PER CENT	CARBON, PER CENT	INSOLUBLE RESIDUE, PER CENT
A...........	77.57	19.36	2.20	0.44	0.19	0.049	0.04
B...........	77.64	19.38	2.20	0.45	0.19	0.040	0.05
C...........	.....	.....	....	0.47	0.18	0.036	0.02
D...........	.....	.....	....	0.36	....	0.033	....
E...........	78.01	19.08	2.28	0.46	0.15	.....	0.00
F...........	.....	19.66	2.22	0.52	0.17	.....	0.04

ANALYSIS OF NICKEL-CHROMIUM-IRON SAMPLES

LABORATORY	NICKEL, PER CENT	CHROMIUM, PER CENT	MANGANESE, PER CENT	IRON, PER CENT	SILICON, PER CENT	CARBON, PER CENT	INSOLUBLE RESIDUE, PER CENT
A...........	63.00	10.79	2.92	22.75	0.19	0.050	0.04
B...........	62.88	10.84	2.94	22.80	0.20	0.044	0.05
C...........	.....	.....	....	23.26	0.18	0.048	0.02
D...........	.....	.....	....	22.58	....	0.035	....
E...........	63.09	10.85	2.79	22.90	0.18	.....	0.07
F...........	62.78	11.30	2.98	.....	0.19	.....	0.05

Before the methods were finally approved they were submitted to Mr. G. E. F. Lundell and Mr. W. A. Cowan, chairmen of the sub-committees on chemical analysis of Committees A-1 on Steel and B-2 on Non-Ferrous Metals and Alloys, respectively. Their comments in comparing the methods with the present methods of chemical analysis for ferrous and non-ferrous metals and alloys were solicited. Minor comments were offered and the methods were modified accordingly. One comment from Committee A-1 resulted in the adoption of the persulfate method for determining chromium. A further comment called attention to the difference in the methods for determining carbon as compared with the present standard methods of analysis for alloy steel. It is generally recognized that the determination of carbon in the alloys in question is considerably more difficult than for carbon in steel, especially when the carbon content is small. While it might have been possible to make the proposed methods correspond more nearly with those for alloy steel there would still be enough difference to require a separate method for the resistance alloys.

In the method for the determination of carbon, reference has been made to the weighing method which is used in alloy steels and it is stated that where the gravimetric method is in constant use and a large number of samples is to be run the gravimetric method is optional with the volumetric method which has been adopted as standard.

While some modifications no doubt could be made in the methods without affecting the results obtained, it seems undesirable to make any further changes at this time until such modifications can be thoroughly checked, since in a number of instances it developed that slight differences in the technique affected the results enormously. The methods are accordingly recommended for publication as tentative in the form submitted.

Tension Test.—The committee proposes that tension tests on resistance materials for electrical heating be made in accordance with the Tentative Methods of Tension Testing of Metallic Materials (Serial Designation: E 8 – 25 T). These methods will accordingly be specified in any specifications for materials the committee may prepare requiring the use of a tension test.

Life Test.—One of the subjects most actively followed during the year is the life test or test for the durability of resistance wire at high temperatures, as this is considered the most important test. A specimen 0.025 in. in diameter has been selected as standard with provisions for testing other sizes. Vertical and horizontal catenary mounting have been compared, and the vertical mounting has been adopted. A modified form of optical pyrometer has been found satisfactory for temperature measurement. While the constant temperature test is preferable theoretically under certain conditions, the constant voltage test has been found more practicable. Both continuous and intermittent tests will be necessary to correspond to service conditions, in electric furnaces and household electrical appliances, respectively. A number of tests have been made showing how the life is affected by the different current cycles with the off and on periods equal and varying from twenty seconds to five minutes. Any intermittent test gives a much shorter life than the continuous test at the same temperature.

A suggested method for the life test at high temperature has been prepared and arrangements have been made for "round robin" tests by nine laboratories.

Standard Sizes and Packages.—A tabulation of sizes of spools used by the different manufacturers indicates substantial agreement and standard sizes are being worked out.

The committee is also endeavoring to obtain agreement by the manufacturers on the colors of labels used to indicate the different kind of resistance wires. This includes resistance wires for use at room temperature as well as at elevated temperatures.

Growth.—A new sub-committee has been organized to study the growth of nickel-chromium resistor materials due to continued and repeated heating in order to determine whether the phenomenon commonly described as growth is such in the true sense of the word or is the result of plastic flow of the metal at high temperature.

Temper.—As a means of determining the uniformity of temper of wire, a comparison is being made of a torsion test and a test for the uniformity of stretch of a helical coil of the wire.

The present Methods of Test for Resistivity of Metallic Materials for Electrical Heating (B 63 - 26 T) are recommended to be continued as tentative in their present form.

The following is a result of the letter ballot vote of the committee, which consists of 15 members, on the recommendations contained in this report.

Items	Affirmative	Negative	Not Voting
1. Submission as tentative of Methods of Chemical Analysis of Metallic Materials for Electrical Heating	13	0	2
2. Submission as tentative of Method of Test for Change of Resistance with Temperature of Metallic Materials for Electrical Heating	13	0	2

This report has been submitted to letter ballot of the committee, which consists of 15 members, of whom 13 have voted affirmatively, none negatively, and 2 have refrained from voting.

Respectfully submitted on behalf of the committee,

DEAN HARVEY,
Chairman.

F. E. BASH,
Secretary.

EDITORIAL NOTE

The proposed Tentative Methods of Chemical Analysis of Metallic Materials for Electrical Heating and the proposed Tentative Method of Test for Change of Resistance with Tempertaure of Metallic Materials for Electrical Heating were accepted for publication as tentative and appear on pages 757 and 740, respectively.

REPORT OF COMMITTEE C-1
ON
CEMENT

Since the last meeting of the Society, Committee C-1 has held two meetings. These were both well attended. The discussions of the reports presented by sub-committees indicated that there was no lapse of interest in the work of the committee although a revision of the Standard Specifications for Cement was presented at the last annual meeting for reference to letter ballot for adoption.

The revision of the standard submitted to the Society at its last annual meeting was adopted by letter ballot on September 1, 1926. Since then a Sectional Committee, functioning under the rules of the American Engineering Standards Committee, under the sponsorship of this Society, has been formed, has held a meeting and has voted to recommend to the American Engineering Standards Committee through the sponsors the adoption of the revised Standard Specifications and Tests for Portland Cement (C 9 – 26) as American Standard No. 1—Revised. The Federal Specifications Board at a meeting on February 8, 1927, ordered the promulgation of these same specifications as a revision of Federal Specifications Board Standard No. 1, with but two changes. In Section 11 the Federal specification will use the word "shall" instead of the word "may," thereby making compulsory the rejection of cement if it fails to meet any of the requirements of the specifications. To Section 50 the Federal Specifications Board added the words "of the American Society for Testing Materials."

By the action of these two organizations, a uniform standard for cement in practically all details has been secured. In adopting the form as well as the substance of the Society's standard the Federal Specifications Board deviated from its well-defined practice of having all its standards conform to one standard form. But it was felt that this was desirable in order to maintain the uniformity in appearance as well as in requirements in the two standards which have existed now for many years. It was also thought that the concession might well be made in view of the action of Committee C-1 in adopting in its revision practically *in toto* the wording which was submitted to it by the Committee on Cement of the Federal Specifications Board.

At a meeting of the committee held on September 18, 1926, a report was presented by Sub-Committee VII on certain tests of fluid cement-water mixtures. This investigation was carried on for the purpose of (1) comparing strength tests on fluid cement-water mixes, standard sand cylinders and briquets made by different laboratories using the same cement, (2) studying the day-to-day uniformity of strength tests, (3) studying the effect of varying quantities of mixing water in cement-water mixtures, (4) studying the flow cylinder test for consistency of fluid cement-water mixtures, and (5) studying the possibilities of a one or three-day strength test for portland cement.

In the Appendix to this report are given in somewhat more detail the scope and the method of carrying out the tests and a very brief summary of the data obtained.

As a result of an analysis of the data, Sub-Committee VII felt that further work should be carried on in this connection but particularly amplifying the work by including more laboratories, and a number of cements instead of one. Accordingly a new program of tests was drawn up in which 52 laboratories are cooperating, using 33 different brands of cement. The investigation includes the following tests: (1) 1:3 standard sand mortar briquets tested at 3, 7 and 28 days and 3 months; (2) neat cement mixed with 42 per cent of water by weight and tested at the end of 3, 7 and 28 days and 3 months, in the form of a 2-in. cube compression test specimen and tension briquets of the usual type; (3) miscellaneous tests including normal consistency, time of setting, soundness and fineness. In addition a smaller number of laboratories used the same cements and tested them in the form of 6 by 12-in. cylinders in a 1:2.4:3.6 concrete.

An attempt was made to have these data in shape to present at this meeting of the Society in the form of a progress report. However, the time required in securing the cement from plants scattered from one coast to the other, preparing the samples and redistributing to laboratories extending from coast to coast, occupied so much time that it was not possible to do this. The data will undoubtedly be at hand and be the principal topic for discussion of the committee at its meeting held during this annual meeting of the Society.

The committee desires in this connection to express its appreciation of the full cooperation given by the Portland Cement Association, which undertook the collection of samples representing the 32 brands of portland cement used in the investigation, as well as the distribution of these samples to the 52 cooperating laboratories.

The present Standard Specifications for Natural Cement (C 10 - 09) has been under the scrutiny of the Sub-Committee on

Natural Cement. The sub-committee recommended the substitution of two new specifications to replace the present one. However, the report of the sub-committee after a thorough discussion was referred back for further consideration. It is believed that during the coming year the present specifications will have been definitely revised. It should be borne in mind, however, that at the present time natural cement, or the cements which have been developed in its place, are used but in very minor quantities and their use is almost entirely restricted to the setting of masonry. As a consequence, the sub-committee has not been able to proceed very rapidly in its study of this problem.

The work which the committee is now carrying on in the study of fluid cement-water mixtures for testing cement, covers the study of a compression test specimen. The committee has therefore not done any further work other than that indicated in the Appendix in the study of a compressive test specimen for mortars of normal consistency. The tests now under way as indicated above include a study of the use of a compression test specimen using the fluid mixtures. Pending the obtaining of these data therefore it is recommended that the present Tentative Specifications and Tests for Compressive Strength of Portland Cement Mortars (C 9 – 16 T) be continued as tentative.

This report has been submitted to letter ballot of the committee, which consists of 75 members, of whom 64 have voted affirmatively, one negatively, and 10 have refrained from voting.

Respectfully submitted on behalf of the committee,

P. H. BATES,
Chairman.

F. H. JACKSON,
Secretary.

APPENDIX

TESTS OF FLUID CEMENT-WATER MIXTURES

Purpose of Tests.—The purpose of these tests of portland cement was:

1. To compare strength tests on fluid cement-water mixtures, standard sand cylinders and briquets made by 12 different laboratories using the same cement.
2. To study the day-to-day uniformity of strength tests.
3. To study the effect of varying the quantity of mixing water in fluid cement-water mixtures,
4. To study the flow cylinder test for consistency of fluid cement-water mixtures, and
5. To study the possibilities of a 1 or 3-day strength test for portland cement.

MATERIALS AND TEST METHODS

Cement.—Each laboratory was furnished with a 230-lb. sample of portland cement which consisted of a mixture of equal parts of 4 brands purchased in Chicago.

Mixing Paste.—1400 g. of cement was used for a batch. The cement-water pastes were mixed in an 8-in. metal stew pan with an 11-in. metal spoon. The water and cement were placed in the pan and 1 minute was allowed for absorption of water; the cement and water were then stirred thoroughly with the spoon for 1 minute.

The pan was immersed in clean water and the inside wiped with a cloth before each mixing.

Consistency.—The consistency of the fluid cement-water mixtures for the strength test was determined by means of the flow test. The flow cylinder consisted of a polished, cylindrical brass tube, inside diameter 60 mm., height 162 mm., provided with a cone-shaped bottom with an included angle of 60 deg.; total capacity 400 cc. The circular bottom orifice, 15 mm. in diameter, was controlled by a quick-acting flap valve. A collar about 3 mm. from the top allowed the surplus cement to be struck off. (See Fig. 1.)

Flow Test.—The flow test was made immediately after mixing; the paste was poured into the flow cylinder and struck off with a straight-edge, the valve released, and the paste dropped 100 mm. onto a clean, dry plate glass.

The flow was expressed in terms of the average diameter of the pat in millimeters measured on 2 diameters by means of 10-in. calipers. The flow cylinder was thoroughly cleaned by immersing in clean water before each test.

The *basic mixture* was that mixture of cement and water which, when tested in the flow cylinder using a 100-mm. drop, gave a flow of 250 mm. The percentage of water required for the basic mixture was determined by making flow tests on 1400-g. batches of cement using 520 and 600 cc. of water and from the flows obtained, interpolating the percentage of water giving a 250-mm. flow.

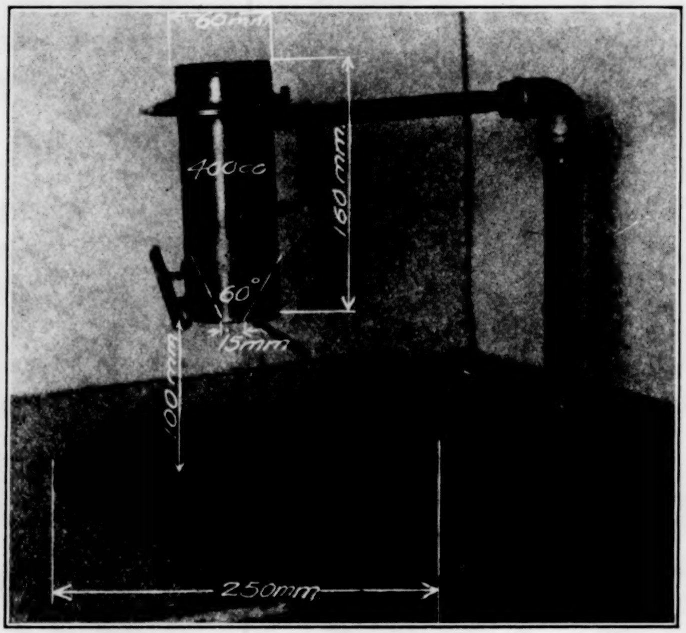

FIG. 1.—Apparatus for Testing Consistency of Fluid Cement-Water Mixtures.

Molding Specimens.—Immediately after making the flow test, the remaining paste was poured into the 2-in. cube molds.[1] The paste was stirred during the pouring operation. Each of the 3 molds in a set were filled one-half full before the operation was repeated and the molds filled to overflowing. Immediately after molding, the specimens were covered with heavy, wet burlap and oilcloth in order to minimize evaporation.

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[1] Laboratories A and B made 2 by 4-in. cylinders instead of 2-in. cubes. Laboratory H made tests on both cubes and cylinders.

Three or four hours after molding, each specimen was levelled with a pointing trowel, covered with a glass plate and the wet burlap and oilcloth replaced.

Curing.—18 to 20 hours after molding, the specimens were removed from the molds and placed in water at 70° F. until tested. The fresh specimens were at no time exposed to the drying action of the room.

The temperatures of the room and mixing water were maintained as nearly as practicable at 70° F.

Testing.—The 2-in. cubes were loaded on the side, that is, perpendicular to the direction of the molding. Specimens which were tested at 1 day were tested within 10 minutes of 24 hours after molding.

STANDARD SAND MORTAR TESTS

Standard sand mortar specimens were molded and tested in accordance with the methods outlined in the Standard Specifications and Tests for Portland Cement (C 9 – 26),[1] the Tentative Specifications and Tests for Compressive Strength of Portland Cement Mortars (C 9 – 16 T),[2] and the Manual of Cement Testing published with the Standard Specifications C 9.

Mixing.—Standard sand mortars were mixed in batches of 750 g. of sand and 250 g. of cement for briquets, and 1200 g. of sand and 400 g. of cement for the cylinders.

Molding.—Briquets were molded by thumbing 12 times on each side, using a pressure of 15 lb. Two by four-in. cylinders were molded in 3 layers, each layer being tamped 25 times with a $\frac{3}{4}$-lb., 1-in. round metal tamper. Immediately after molding, the specimens were trowelled and covered with wet burlap and oilcloth. The 2 by 4-in. cylinders were capped with retempered neat cement 3 or 4 hours after molding and re-covered with wet burlap and oilcloth.

Curing and Testing.—The same procedure was followed as for fluid cement-water mixtures.

CONCLUSIONS

The principal data of these tests are summarized in Tables I to III and lead to the following conclusions:

This investigation is somewhat inconclusive from the standpoint of uniformity of tests on a given cement by the 12 laboratories using

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[1] A.S.T.M. Standards Adopted in 1926.

[2] *Proceedings*, Am. Soc. Testing Mats., Vol. XX, Part I, p. 599 (1920); also 1926 Book of A.S.T.M. Tentative Standards, p. 242.

TABLE I.—SUMMARY OF COMPRESSION TESTS OF NEAT CEMENT

Compression tests of 2-in. cubes except the specimens of Laboratory A and the 90 per cent basic specimens of Laboratory B which were 2 by 4-in. cylinders.

Each value is the average of 12 or 15 tests.

Mean variations are average deviations of 4 or 5 rounds for a given laboratory or of different laboratories from their averages expressed as percentages.

Laboratory	Mixing Water		Flow, mm.	Compressive Strength, lb. per sq. in.				Mean Variations in Compressive Strength for Different Rounds, per cent			
	Per Cent of Basic	Per Cent by Weight		1 Day	3 Days	7 Days	28 Days	1 Day[a]	3 Days[a]	7 Days[a]	28 Days[a]
A	90	36.2	214	1270	2530	4290	7330	2.8 (1.8)	1.2 (2.4)	3.7 (1.6)	1.6 (4.9)
	100	40.3	250	780	1860	3220	6320	3.2 (1.2)	3.5 (2.4)	4.8 (2.1)	4.7 (2.0)
	110	44.4	276	640	1470	2480	5600	3.9 (4.0)	3.6 (1.8)	6.1 (1.6)	5.2 (1.3)
B	90	36.7	212	790	2590	4670	9180	8.9 (2.4)	2.5 (2.3)	4.2 (2.8)	3.3 (1.5)
	100	40.7	243	490	1850	3340	7490	8.6 (1.8)	3.7 (2.6)	4.4 (1.9)	3.6 (2.5)
	110	44.7	272	410	1480	2720	6520	11.2 (2.1)	4.9 (1.8)	3.4 (1.9)	4.9 (2.5)
C	90	39.9	218	710	2020	3710	7150	6.2 (2.3)	2.2 (1.5)	4.3 (2.7)	4.2 (2.1)
	100	44.3	247	540	1530	2710	6030	11.0 (1.9)	4.3 (2.3)	8.6 (4.5)	4.9 (2.0)
	110	48.7	286	410	1270	2320	5220	6.8 (2.0)	1.4 (2.1)	4.9 (5.0)	2.0 (4.1)
D	90	38.1	215	520	1660	3050	7240	11.5 (3.4)	8.7 (5.1)	5.2 (3.1)	4.2 (2.2)
	100	42.3	258	380	1250	2500	6310	6.8 (4.1)	2.9 (3.5)	3.4 (3.4)	4.5 (3.0)
	110	46.5	285	280	940	1990	5440	17.9 (5.0)	6.0 (4.0)	6.0 (1.8)	2.4 (3.5)
E	90	37.0	216	630	1790	3290	7520	7.3 (3.4)	6.0 (2.7)	5.7 (4.1)	3.6 (1.3)
	100	41.1	252	450	1320	2470	6610	6.7 (3.4)	5.0 (2.7)	3.0 (3.0)	3.5 (5.4)
	110	45.2	290	360	1030	1970	5750	10.0 (2.9)	7.6 (3.6)	4.0 (2.8)	1.7 (2.4)
F	90	37.3	201	705	1670	2890	6800	7.0 (8.7)	10.5 (3.5)	2.1 (5.1)	5.5 (4.5)
	100	41.5	245	415	1200	2330	5280	6.8 (5.5)	5.0 (5.1)	6.7 (7.4)	5.0 (6.2)
	110	45.6	279	240	880	1720	4850	9.4 (7.3)	2.7 (4.6)	3.7 (3.1)	0.3 (2.2)
G	90	37.2	218	840	2310	4040	7370	11.2 (2.7)	6.1 (2.5)	6.1 (2.4)	3.8 (5.7)
	100	41.4	252	590	1710	2900	5750	14.2 (2.7)	7.7 (2.9)	5.9 (2.0)	6.8 (5.3)
	110	45.5	285	470	1310	2420	5320	22.6 (2.7)	11.1 (3.4)	10.5 (2.4)	7.1 (5.2)
H	90	35.7	221	840	2050	3610	7370	3.8 (2.5)	3.1 (4.0)	1.7 (5.5)	3.6 (6.2)
	100	39.7	250	610	1440	2800	6400	5.3 (2.6)	4.0 (2.8)	4.0 (2.6)	2.9 (4.0)
	110	43.7	276	450	1170	2240	5660	6.2 (2.0)	2.7 (3.0)	3.0 (2.8)	4.0 (4.6)
I	90	36.0	200	680	2380	4420	8090	15.6 (5.1)	3.8 (5.1)	7.3 (5.6)	8.9 (7.7)
	100	40.0	250	440	1870	3170	6130	17.3 (4.4)	3.3 (3.7)	4.4 (5.8)	4.4 (2.6)
	110	44.0	270	310	1320	2560	5430	18.1 (5.9)	3.6 (5.5)	4.8 (5.0)	4.5 (8.9)
J	90	37.4	224	940	2390	4220	7500	+11.7 (1.1)	6.0 (0.8)	2.4 (0.6)	... ...
	100	41.5	252	680	1960	3390	6460	5.9 (1.0)	4.7 (0.8)	0.9 (0.5)	2.3 (0.7)
	110	45.7	269	490	1420	2390	4960	10.2 (2.0)	3.2 (0.8)	1.2 (1.3)	1.1 (0.4)
K	90	35.1	216	900	2090	3320	6860	4.2 (3.0)	9.1 (2.8)	9.8 (3.8)	1.7 (1.6)
	100	39.0	248	640	1590	2710	6070	3.1 (2.3)	6.1 (2.2)	3.4 (5.6)	4.9 (5.2)
	110	42.9	259	410	1290	1960	4910	9.8 (3.9)	5.3 (2.4)	10.8 (6.8)	2.2 (4.6)
L	90	36.7	213	750	2600	4340	7720	8.0 (5.2)	3.1 (2.9)	1.4 (2.9)	3.3 (3.3)
	100	40.7	252	460	1770	2990	6140	9.1 (3.9)	3.4 (2.7)	2.4 (2.8)	4.3 (3.2)
	110	44.8	281	370	1420	2520	5450	9.2 (6.1)	4.5 (2.3)	3.7 (2.1)	3.3 (4.0)
Average	90	36.9	214	800	2170	3820	7510	8.2 (3.5)	5.2 (3.0)	4.5 (3.4)	4.0 (3.7)
Mean variation	....	2.4	2.3	16.7	13.5	13.4	5.5	... ...	... ...	... ...	... ...
Average	100	41.1	250	540	1610	2880	6250	8.2 (2.9)	4.5 (2.8)	4.3 (3.5)	4.3 (3.5)
Mean variation	....	2.4	1.1	18.6	13.9	10.1	5.6	... ...	... ...	... ...	... ...
Average	110	45.1	278	400	1250	2270	5420	11.3 (3.8)	4.7 (2.9)	5.2 (3.1)	3.2 (3.6)
Mean variation	....	2.4	2.5	19.1	13.1	11.0	5.8	... ...	... ...	... ...	... ...

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[a] Values in parenthesis are the averages of the mean variations of three specimens from a single batch from their average.

TABLE II.—SUMMARY OF COMPRESSIVE TESTS OF 1:3 STANDARD SAND MORTARS.

Each value is the average of 12 or 15 tests.

Mean variations are average deviations of 4 or 5 rounds for a given laboratory or of different laboratories from their averages expressed as percentages.

Laboratory	Type of Speci-men	Mixing Water, per cent by weight	Compressive Strength, lb. per sq. in.				Mean Variations in Compressive Strength for Different Rounds, per cent			
			1 Day	3 Days	7 Days	28 Days	1 Day[a]	3 Days[a]	7 Days[a]	8 Days[a]
A............	2 by 4	42.0	510	1430	2230	4060	7.4 (1.8)	5.6 (1.7)	5.6 (1.5)	2.7 (3.4)
	Briq.	42.0	105	230	290	420	2.5 (3.2)	5.5 (2.7)	1.7 (3.3)	3.0 (1.8)
B............	2 by 4	41.6	580	1480	2520	4090	3.9 (4.9)	6.6 (4.7)	4.2 (3.7)	1.8 (4.5)
	Briq.	41.6	110	205	280	385	9.1 (4.0)	3.0 (4.5)	4.3 (2.7)	1.6 (4.0)
C............	2 by 4	40.8	590	1350	2010	2780	12.2 (3.1)	7.3 (5.2)	3.5 (7.7)	10.1 (4.5)
	Briq.	40.8	125	195	250	330	14.4 (5.1)	6.7 (5.6)	4.0 (6.9)	2.7 (8.9)
D............	2 by 4	42.0	450	1240	1900	3350	4.9 (3.4)	3.2 (4.2)	4.0 (7.5)	4.8 (6.1)
	Briq.	42.0	80	200	280	370	6.3 (4.5)	6.0 (6.0)	3.6 (3.3)	2.2 (4.1)
E............	2 by 4	41.5	400	1040	1660	2850	18.1 (4.9)	7.2 (5.6)	9.3 (4.3)	16.1 (9.4)
	Briq.	41.5	85	190	275	400	11.8 (11.2)	6.3 (6.1)	3.3 (4.0)	4.5 (2.7)
F............	2 by 4	42.5	405	770	1380	2080	9.9 (4.1)	14.7 (7.9)	13.3 (7.7)	17.2 (11.2)
	Briq.	42.5	85	180	240	300	11.8 (7.5)	1.7 (3.4)	2.9 (4.5)	7.0 (3.0)
G............	2 by 4	42.0	680	1370	2160	3050	6.2 (3.6)	6.4 (7.3)	3.5 (4.8)	7.1 (5.6)
	Briq.	42.0	115	215	280	385	3.5 (5.9)	3.7 (3.8)	5.0 (4.2)	3.9 (5.3)
H............	2 by 4	41.6	510	1270	2040	3670	2.7 (4.3)	4.3 (7.5)	4.7 (7.2)	4.7 (7.8)
	Briq.	41.6	135	235	305	415	8.9 (4.4)	4.3 (4.7)	3.3 (6.3)	3.4 (4.2)
I............	2 by 4	42.5	270	1020	1680	2270	19.3 (5.9)	9.3 (6.1)	18.8 (6.9)	13.1 (15.9)
	Briq.	42.5	45	190	270	385	24.4 (6.6)	6.3 (3.0)	3.7 (2.5)	2.9 (3.3)
J............	2 by 4	....	....	....	....	....	... ...	... ...	... ...	... ...
	Briq.	42.0	115	210	275	400	0.9 (1.4)	5.7 (1.3)	1.8 (0.7)	0.3 (0.6)
K............	2 by 4	43.3	330	920	1680	2860	3.0 (5.7)	7.9 (2.0)	7.5 (3.6)	11.5 (8.4)
	Briq.	43.3	65	195	285	400	10.1 (4.0)	6.8 (3.2)	3.5 (3.1)	1.7 (2.4)
L............	2 by 4	41.6	540	1550	2310	3740	12.5 (3.7)	7.1 (4.0)	1.8 (4.0)	2.5 (4.7)
	Briq.	41.6	105	210	265	370	7.6 (4.4)	7.2 (5.7)	2.3 (6.0)	4.3 (6.1)
Average.........	2 by 4	41.9	480	1220	1960	3160	9.1 (4.1)	7.2 (5.1)	6.9 (5.4)	8.3 (7.4)
Mean variation..	......	1.1	20.3	17.0	13.9	17.8	... ...	... ...	... ...	... ...
Average.........	Briq.	41.9	100	205	275	380	9.3 (5.2)	5.3 (4.2)	3.3 (4.0)	3.1 (3.9)
Mean variation..	......	1.1	20.9	6.3	4.6	6.6	... ...	... ...	... ...	... ...

[a] Values in parenthesis are the averages of the mean variations of three specimens from a single batch from their average.

TABLE III.—SUMMARY OF MEAN VARIATION IN COMPRESSIVE STRENGTH TESTS FROM TABLES I AND II.

Mixture		Mean Variation of Twelve Laboratories from their Average, per cent				Average Mean Variation for Different Rounds, per cent				Grand Average of Mean Variations of Three Specimens from a Batch, per cent			
		1 Day	3 Days	7 Days	28 Days	1 Day	3 Days	7 Days	28 Days	1 Day	3 Days	7 Days	28 Days
90 per cent of Basic...	2-in. cubes	16.7	13.5	13.4	5.5	8.2	5.2	4.5	4.0	3.5	3.0	3.4	3.7
100 per cent of Basic...		18.6	13.9	10.1	5.6	8.2	4.5	4.3	4.3	2.9	2.8	3.5	3.5
110 per cent of Basic...		19.1	13.1	11.0	5.8	11.3	4.7	5.2	3.2	3.8	2.9	3.1	3.6
Average....................		18.1	13.5	11.5	5.6	9.2	4.8	4.7	3.8	3.4	2.9	3.3	3.6
1:3 mortar (2 by 4-in. cylinders)..		20.3	17.0	13.9	17.8	9.1	7.2	6.9	8.3	4.1	5.1	5.4	7.4
1:3 mortar (briquets)............		20.9	6.3	4.6	6.6	9.3	5.3	3.3	3.1	5.2	4.2	4.0	3.9

fluid cement-water mixtures in the form of 2-in. cubes as compared with 1:3 standard sand briquets.

When the two forms of test are compared on the basis of day-to-day variation for a given laboratory and the variation of the three specimens from the same batch, the fluid cement-water mixtures give more favorable results.

When the data from the 12 laboratories are compared it will be noted from Table III that the present standard mortar briquet gives the most favorable results. However, the data submitted by the laboratories may be considered fairly representative of the results from operators of long experience in the making of standard briquet tests, but inexperienced in the use of the fluid cement-water mixtures. While earlier tests indicated that experience was not essential with the fluid cement test, it appears that with longer use of this method of testing cement and a more careful control of temperature, better results would be secured.

The use of a fluid cement mix containing about 41 per cent of water by weight of cement seems to be most suitable for a compression test.

The fluid neat cement mixture presents the possibility of a 3-day test with fairly uniform results. The 3-day strengths for 100 per cent basic mixture in this investigation were about 25 per cent of the 28-day strengths.

REPORT OF COMMITTEE C-3

ON

BRICK

Committee C-3 has held three meetings during the past year. Nine new members were added to the committee; three deaths and one resignation made a net increase of five, making the present membership forty-one.

Sub-Committee V on Chemical Requirements for Sewer Brick and Sub-Committee XI on Face Brick were discharged. Two new sub-committees, Sub-Committee XII, Editorial, and Sub-Committee XIII on Weathering and Porosity, were formed.

The chief activity of the committee has been the revision of the existing standards from the standpoint: first, of making them conform to the latest technical information available; and, second, the separation of the specification proper from the method of test.

The feature of the new Tentative Specifications for Building Brick (Made from Clay or Shale), appended hereto,[1] which bases the classification mainly on the flat compressive strength of individual brick is based in part on recent investigations at the U. S. Bureau of Standards. A very important paper by H. Kreuger, Professor of Structural Engineering, Tekniska Hogskolan, Stockholm, Sweden, entitled "Investigation on Climatic Action on the Exterior of Buildings" has also been used by the committee. Steps are being taken to make this paper available for use in the United States.

It is the recommendation of Committee C-3 that in the reprinting of specifications in pamphlet form the methods of test specified in the given specification be printed with the specifications.

Committee C-3 offers the following recommendations:

1. That the Standard Specifications for Building Brick (C 21 - 20)[2] be withdrawn;

2. That the proposed Specifications for Building Brick (Made from Clay or Shale), appended hereto,[1] be accepted for publication as tentative;

3. That the proposed Specifications for Paving Brick, appended hereto,[3] be accepted for publication as a tentative

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[2] 1924 Book of A.S.T.M. Standards.

[1] See p. 803.—Ed.

[3] See p. 805.—Ed.

revision of the present Standard Specifications for Paving Brick (C 7 - 15);[1]

4. That the proposed Methods of Testing Brick, appended hereto,[2] be accepted for publication as tentative.

The committee presents the following definition for the term "brick" as a suggested definition, published as information to elicit suggestions and criticisms:

> "*Brick.*—A structural unit formed while plastic into a rectangular prism, usually solid and 8 by 3¾ by 2¼ in. in size.
>
> "*Note.*—The term 'brick' is understood to mean a unit of burned clay or shale. When other substances are used, such as lime and sand, cement and sand, fire clay, adobe, etc., the term 'brick' should be suitably qualified."

Committee C-3 has acted in cooperation with Committee E-8 on Nomenclature and Definitions in the preparation of this definition.

It is expected that the remaining standards and tentative standards now on the Society's books will be withdrawn in 1928 and new tentative standards offered in their places, as well as Tentative Specifications for Sand-Lime Brick and for Concrete Brick.

The second important action of Committee C-3 has been the formation of a Sub-Committee on Weathering and Porosity. It is hoped ultimately to provide a laboratory test for estimating resistance to weathering, and thus make this very important property subject to specification.

The recommendations appearing in this report have been submitted to letter ballot of the committee with the following results:

Item	Affirmative	Negative	Not Voting
Submission as information of Definition for the Term "Brick"	29	10	2
Withdrawal of present Standard Specifications for Building Brick (C 21 - 20)	31	7	3
Submission of Tentative Specifications for Building Brick	37	1	3
Submission of Tentative Specifications for Paving Brick	33	1	7
Submission of Tentative Methods of Testing Brick	37	2	2

This report has been submitted to letter ballot of the committee, which consists of 41 members, of whom 39 have voted affirmatively, none negatively, and 2 have refrained from voting.

Respectfully submitted on behalf of the committee,

T. R. LAWSON,
Chairman.

J. W. MCBURNEY,
Secretary.

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[1] 1924 Book of A.S.T.M. Standards.

[2] See p. 826.—ED.

EDITORIAL NOTE

The proposed Tentative Specifications for Building Brick (Made from Clay or Shale) were accepted for publication as tentative to replace the present Standard Specifications for Building Brick and appear on page 803. The Standard Specifications for Building Brick were withdrawn. The proposed Tentative Specifications for Paving Brick were accepted for publication as tentative as a revision of the present Standard Specifications for Paving Brick and appear on page 805. The proposed Tentative Methods of Testing Brick were accepted for publication as tentative and appear on page 826.

REPORT OF COMMITTEE C-4

ON

CLAY AND CEMENT-CONCRETE PIPE

The committee has held two meetings during the past year.

At the meeting held during the annual meeting of the Society, attended by seven non-producer members and fourteen producer members, action was taken toward amending the specifications for clay and cement-concrete sewer pipe, by approving sub-committee reports recommending:

The addition of 5-in. pipe for both clay and concrete products;

The elimination of 39-in. and 42-in. pipe in the clay product;

The increase by definite amounts of the depth of sockets and the inside diameter of sockets for 4-in. to 36-in. pipe in the clay product;

The modification by definite amounts in the permissible variation of inside diameter at spigot and socket for 10-in. to 36-in. pipe in the clay product;

The addition of a light-weight pipe of definite dimensions for 15-in. to 36-in. sizes of the clay product;

The elimination of the cautionary footnote, heretofore accepted for publication as tentative, for inclusion in the Specifications for Cement-Concrete Sewer Pipe (C 14 – 24), provided all reference to the pipe as sewer pipe be omitted in the title of the committee and in the specifications for both the clay and the cement-concrete products.

The officers of the committee were authorized to submit a revised draft of the specifications to conform with the foregoing proposed amendments.

The proposed change in the title of the committee to Committee C-4 on Clay and Cement-Concrete Pipe was later approved by the Executive Committee of the Society.

At the meeting of March 11, 1927, attended by eight non-producer members and fourteen producer members, drafts of the proposed amendments to the following standards and tentative standards were presented but further action was deferred until the June meeting to give the manufacturing interests time for further consideration of certain matters:

Standard Specifications for Clay Sewer Pipe (C 13 – 24);
Standard Specifications for Cement-Concrete Sewer Pipe (C 14 – 24);
Standard Definitions of Terms Relating to Sewer Pipe (C 8 – 24);
Recommended Practice for Laying Sewer Pipe (C 12 – 19);
Tentative Specifications for Required Safe Crushing Strengths of Sewer Pipe to Carry Loads from Ditch Filling (C 15 – 17 T).

At this meeting it was decided by unanimous vote to recommend to the Executive Committee of the Society that the two products, clay pipe and cement-concrete pipe, be allotted to two separate committees. No action in the matter has been taken by the Executive Committee at the time of the preparation of this report.

It is recommended that the Tentative Specifications for Required Safe Crushing Strengths of Sewer Pipe to Carry Loads from Ditch Filling (C 15 – 17 T) and the cautionary footnote printed as a tentative revision of Specifications C 14 – 24 be continued as tentative for another year.

This report has been submitted to letter ballot of the committee, which consists of 29 members, of whom 14 have voted affirmatively, one negatively, and 14 have refrained from voting.

Respectfully submitted on behalf of the committee,

ANDREW J. PROVOST, JR.,
Chairman.

GEORGE T. HAMMOND,
Vice-Chairman.

EDWARD S. RANKIN,
Secretary.

REPORT OF COMMITTEE C-6
ON
DRAIN TILE

The Standard Specifications for Drain Tile (C 4 – 24) as prepared by Committee C-6 and now adopted as standard for the United States by the American Engineering Standards Committee do not contain any very definite test methods or standard requirements as to the chemical or the mineralogical constitution of the materials (burnt clay or concrete) in the shell of the tile. It was recognized at the time the specifications were prepared that this was an omission that ought to be remedied as soon as scientific research could be carried on to develop reliable and reasonable methods and standards. Consequently, the committee has been engaged for several years in promoting and coordinating a number of researches in this general line, especially with concrete tile. The resistance of concrete to alkali and acid soil condition attack has been the main subject of these researches.

The agencies engaged in making these studies are the Iowa Engineering Experiment Station, the Structural Materials Research Laboratory of Lewis Institute with the cooperation of the Portland Cement Association, the Engineering Institute of Canada, and the United States Bureau of Public Roads with the cooperation of the University of Minnesota and the Department of Drainage and Waters, State of Minnesota. Progress reports of these researches have been made annually in the reports of Committee C-6.

These researches have not as yet developed laboratory tests and requirements which the committee has considered should be adopted and inserted in the specifications, but the work is being continued with considerable activity.

Brief abstracts of the reports of the work done during the past year by two of the above-mentioned agencies follow.

I. IOWA ENGINEERING EXPERIMENT STATION

Admixtures for Rendering Concrete Impregnable to Alkali Attack.

(By George W. Burke)

The specimens used for this work were 2 by 4-in. cylinders made up from 1 part of cement to 3 parts of sand on a weight basis. The cement employed was obtained by mixing equal parts of three brands of portland cement.

For practice in preparation, and at the same time to determine the water-cement ratio that would give the strongest concrete, a series of cylinders was made up having water-cement ratios varying from 0.3 to 1.1 by one-tenth differences. The cylinders were cured under hard water for 28 days. After curing, three cylinders of each ratio were tested for compressive strength, three were tested for absorption, three were immersed in 1-per-cent Na_2SO_4, and three in 1-per-cent $MgSO_4$ solution. The cylinders for immersion contained brass slugs in each end for the purpose of measuring any changes in length. The solutions were renewed every two weeks at which times measurements were made. After six months of such treatment, those cylinders having water-cement ratios greater than 0.8 showed cracks on the ends. These cylinders also showed greatest elongation.

Using the methods as described above, cylinders containing various admixtures (largely inorganic salt) were subjected to the immersion test in order to compare the effect of various quantities of many admixtures as to their capacity in rendering concrete more resistant to alkali attack. The character and functions of the admixtures are as follows:

1. Soluble salts to produce insoluble compounds with the lime of the cement.
2. Soluble salts to produce insoluble compounds when reacted upon by the alkali sulfates.
3. Insoluble inert materials and fillers.
4. Insoluble materials of a colloidal nature.
5. For carbonization of the caustic lime set free by hydration.

Some 400 cylinders have been made and are under treatment, but sufficient time has not elapsed to observe any changes.

In order to correlate between physical reaction, physical destruction, and chemical reaction, the exact chemical changes taking place are being measured on other sets of similar cylinders. The data obtained by this work will demonstrate the true relation between physical and chemical reaction taking place and the value of each as an index of failure.

II. U. S. BUREAU OF PUBLIC ROADS

In cooperation with the Department of Agriculture, University of Minnesota, and the Department of Drainage and Waters of the State of Minnesota, the Bureau of Public Roads, U. S. Department of Agriculture, is continuing the investigation relative to drain tile at University Farm, St. Paul, Minn. The work is under the direction of Mr. D. G. Miller, Drainage Engineer.

The work of the laboratory for the past year has been conducted along lines similar to those reported in detail a year ago.[1] The number of experimental concrete cylinders exposed to the action of sulfate waters and of peat has been somewhat increased, and it is expected that sometime during the current year a progress report based on this work will be issued, which will make available much data not heretofore published.

All portland-cement concrete specimens cured in steam at temperatures between 212 and 285° F. continue to show high resistance to the deleterious action of sulfate waters. Steam-cured specimens, after exposure for five years, come up for test within the next few weeks, and judging from change of volume measurements and appearances, they should test very nearly normal strength. Comparable water-cured specimens had practically completely disintegrated at forty weeks.

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 26, Part I, p. 234 (1926).

A surprising difference of resistance to the action of the sulfate waters has been noted among concrete cylinders made of different brands of standard portland cement. Tests now being run along this line on something more than thirty different brands of cement have given results ranging all the way from complete disintegration of concrete cylinders at thirty weeks to as high as 90 per cent of normal strength at two years, indicating the necessity for developing a standard test for portland cement to be used in concrete to be exposed to the action of sulfate waters.

Experimental and mathematical studies of drain tile tests with particular relation to the effect of testing tile in different bearings have recently been completed, and manuscript is now ready for submission for publication. It is probable that this bulletin will be available by the middle of the summer.

Committee C-6 has held one meeting during the year, that of February 25 in Chicago. A second meeting is planned at the time of the annual meeting of the Society in order to consider fully the future activities of the committee.

This report has been submitted to letter ballot of the committee, which consists of 20 members, of whom 13 have voted affirmatively, none negatively, and 7 have refrained from voting.

Respectfully submitted on behalf of the committee,

ANSON MARSTON,
Chairman.

G. W. PICKELS,
Secretary.

REPORT OF SOCIETY REPRESENTATIVES
ON
JOINT COMMITTEE ON CONCRETE CULVERT PIPE

The Joint Committee on Concrete Culvert Pipe was organized in 1919 and consists of two representatives from each of the following:

American Association of State Highway Officials;
American Concrete Institute;
American Concrete Pipe Association;
American Railway Engineering Association;
American Society of Civil Engineers;
American Society for Testing Materials;
Bureau of Public Roads, U. S. Department of Agriculture.

In February, 1926, the committee submitted to the constituent organizations a report in the form of tentative standard specifications for reinforced-concrete culvert pipe.[1] These included general provisions relative to materials and workmanship and prescribed methods of testing and test load limits for the several sizes in each class of pipe. Tables giving the dimensions, quantity of steel and similar data that are required by the manufacturer in order to produce pipe that will meet the test requirements were also included. The basis of design employed in preparing the tables was given so as to permit the design of pipe with concrete of strengths other than those assumed in preparing the design tables.

The tentative specifications of 1926 covered two classes of culvert pipe as follows:

1. *Standard reinforced-concrete culvert pipe* which are intended for use in ordinary highway construction and for railway and interurban service under the lighter loads.
2. *Extra-strength reinforced-concrete culvert pipe* which are intended for use in ordinary railway service and for the higher embankments sometimes encountered in highway construction.

Following the submission of this report, various suggestions for modifications of the tentative specifications were made and the merits of these have been under consideration by the committee during the past year.

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[1] This report was submitted to the Executive Committee of the Society on April 13, 1926, and upon later recommendation of the Society's representatives, consideration by the Executive Committee was postponed pending further study of the report by the joint committee.—ED.

It was contended that pipe could be manufactured with less steel than required by the design tables in the tentative specifications of 1926, and still meet the test strength provisions of those specifications. In order to develop the facts with reference to this point an extensive series of tests has been carried out during the past year. Pipe in which the amounts of steel varied from 25 per cent to 100 per cent of that provided for in the design tables of the tentative specifications, were made and tested. As a result of these tests it was concluded that the quantity of steel required by the tentative specifications could be reduced about 20 per cent and still secure pipe that would comply with the test requirements as to strength. Accordingly, new tables of typical designs providing for this reduction have been prepared.

A consideration of the normal field of use and various other facts presented to the committee has led to the conclusion that the Extra-Strength Pipe should be required to meet a somewhat higher test load than provided for in the tentative specifications of 1926. This change is being included in the revised specifications.

The committee was requested to include an absorption test in the revised specification. This immediately raised a number of questions with reference to the kind of absorption test best adapted to this class of pipe and the size and shape of the test specimen. A tentative specification for a test was developed on the basis of the Society's standard absorption test for cement-concrete sewer pipe, although some modifications were necessary. After the test method had been worked out, a study was undertaken to establish an appropriate limit for the percentage of absorption. This part of the standardization work is not yet complete.

There has been a number of minor changes in the arrangement and wording of the tentative specifications of 1926 and a slight modification of the basis of design. These are for the most part in the interest of clearness and exactness.

The committee has completed its work of revision of the tentative specifications of 1926, except for finally deciding upon the percentage of absorption to allow. There have been three meetings of the committee and four sub-committee meetings during the year and at the most recent meeting of the committee the final form of the revised specifications was agreed upon by the members present. As soon as the absorption question is finally settled, the proposed revised specifications in their entirety will be submitted to a letter ballot of the committee. It is expected that at an early date the committee will authorize the submission to the constituent organizations, of a report embodying revised tentative specifications for reinforced-concrete culvert pipe for adoption as tentative standards. Eventually it is expected that these will become standard specifications of the Society and be submitted for adoption by the American Engineering Standards Committee.

This Society should at this time determine what procedure it will adopt in furtherance of the proposal to have these specifications adopted by the Society as tentative standards.

Respectfully submitted,

ANSON MARSTON
ASA E. PHILLIPS

A.S.T.M. Representatives, Joint Committee on Concrete Culvert Pipe.

REPORT OF COMMITTEE C-7

ON

LIME

Committee C-7 has held two regular meetings since the last annual meeting of the Society.

The various activities of Committee C-7 are grouped below in order of the respective sub-committees.

Sub-Committee II on Lime for Structural Purposes.—Tentative Specifications for Sand for Use in Lime Plaster have been prepared and are presented with the recommendation that they be accepted for publication as tentative, as appended hereto.[1] The sub-committee consulted with various interested organizations and made use of data developed by the U. S. Bureau of Standards, the National Lime Association, and the National Sand and Gravel Association, in preparation of these specifications.

Sub-Committee III on Lime for Chemical Industries.—The Secretary of the Society questioned if the Society should accept specifications for materials that fix a standard without specifying rejection limits. At his suggestion, the sub-committee prepared for the Executive Committee a brief which presented the arguments in favor of the acceptance of such specifications. The Executive Committee ruled that "such specifications may be prepared by the committee (Committee C-7) and submitted to the Society provided that a suitable explanatory note is included with such specifications." Such a note has been prepared. Existing specifications to which it is applicable have been edited accordingly. These specifications are the following:

Standard Specifications for Quicklime and Hydrated Lime for Use in the Cooking of Rags for the Manufacture of Paper (C 45 - 25).

Tentative Specifications for Quicklime for Use in Water Treatment (C 53 - 25 T).

Tentative Specifications for Hydrated Lime for Use in Water Treatment (C 54 - 25 T).

Members of the sub-committee are taking active part in research work to correlate physical properties of lime with the manner in which it functions in various processes with a view to determine the desirability of including these properties, such as bulking, rate of settling, etc., in specifications. Through cooperation with the Lime Section of the Bureau of Standards and the Interdepartmental Conference on Chemical Lime complete analyses of some 36 commercial limes have been published and are now available for consideration in preparation of specifications for lime for use in chemical industries.

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[1] See p. 774.—Ed.

The following tentative specifications have been tentative for two years, during which time no criticisms have been received. They are recommended to the Society for advancement to standard:

Tentative Specifications for Quicklime for Use in the Manufacture of Sulfite Pulp (C 46 - 25 T);[1]

Tentative Specifications for Hydrated Lime for the Manufacture of Varnish (C 47 - 22 T);[2]

Tentative Specifications for Quicklime for Use in Water Treatment (C 53 - 25 T);[1]

Tentative Specifications for Hydrated Lime for Use in Water Treatment (C 54 - 25 T).[1]

Sub-Committee V on Methods of Tests.—The Tentative Methods of Sampling, Inspection, Packing and Marking of Quicklime and Lime Products (Serial Designation C 50 - 24 T)[3] having been tentative for more than two years, during which time no criticisms have been received, are recommended to the Society for advancement to standard.

The sub-committee presents additions and revisions to the Tentative Methods of Chemical Analysis of Limestone, Quicklime and Hydrated Lime (Serial Designation C 25 - 26 T)[4] as follows:

Under "Treatment of Sample," second paragraph, change "0.5 g." in the first sentence to read "approximately 0.5 g."

In the same sentence, immediately after the word "substance" add in parenthesis the following: "(Note 1)."

In the notes given at the end of the Methods of Analysis insert a new Note 1 to read as follows, renumbering the succeeding notes accordingly:

"NOTE 1.—Due to the rapidity with which quicklime and hydrated limes become contaminated by absorption of water and carbon dioxide from the air, samples must be protected in tightly stopped containers at all times. Samples for analysis are to be weighed from stoppered weighing bottles, the exact weight of the samples being determined by the difference in weight of the bottles before and after their removal."

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 25, Part I, pp. 612, 614, 616 (1925); also 1926 Book of A.S.T.M. Tentative Standards, pp. 247, 252, 254.

[2] *Proceedings*, Am. Soc. Testing Mats., Vol. 22, Part I, p. 701 (1922); also 1926 Book of A.S.T.M. Tentative Standards, p. 249.

[3] *Proceedings*, Am. Soc. Testing Mats., Vol. 24, Part I, p. 844 (1924); also 1926 Book of A.S.T.M. Tentative Standards, p. 304.

[4] *Proceedings*, Am. Soc. Testing Mats., Vol. 26, Part I, p. 770 (1926); also 1926 Book of A.S.T.M. Tentative Standards, p. 290.

Under "Determination of Mechanical Moisture" delete the words "only" and "note 19" in the sub-heading, making the sub-heading read "Limestone."

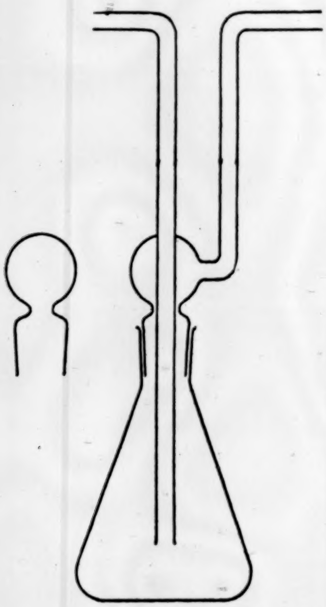

FIG. 1.—Bottle for Determination of Superficial Moisture.

Immediately following the present method under Determination of Mechanical Moisture add a new method to read as follows:

"*Hydrated Lime.*—Mechanical moisture in hydrated limes is to be determined by aspirating over the sample, in a closed container at 120° C. a slow stream of dry, CO_2-free air. The container for the sample is to be equipped with two interchangeable stoppers, one to be used during weighings and the other to be used during the drying. The second stopper is equipped with two entry tubes for conducting the air stream over the sample. (Note 20.) (See Fig. 1.)

"The container is connected in a train, having before it a soda-lime tower, a lime-water bottle, a sulfuric acid bottle, and a phosphoric anhydride bulb, in the order named, and after it another protective phosphoric anhydride bulb. The lime-water bottle is useful for giving indication of the exhaustion of the soda-lime. The train is placed in position, with connection for the sample bottle, in a drying oven at 120° C.

"The manipulations are as follows: Place 2.5 to 3 g. of the properly prepared sample into the previously weighed bottle, and immediately re-stopper it. A glazed paper funnel will aid rapid manipulation. Insert the bottle in the train by quickly exchanging the stoppers, and draw a slow current of dry, CO_2-free air through the apparatus for 2 hours. Remove the sample bottle from the oven with another quick exchange of stoppers, and set it in a desiccator to cool. When cool, remove it to the balance case for several minutes before weighing it, and just before weighing, lift the stopper slightly for an instant to relieve any vacuum that may exist in the bottle. The loss in weight of the sample represents 'Mechanical Moisture' or 'Hydroscopic Water' at 120° C.

"Use a bottle similar to the one containing the sample as a counterpoise in all weighings.

"Note 20.—A little bottle of 20 to 30-cc. capacity with glass stoppers, as described, ground to fit, is a convenient form of apparatus. (See Fig. 1.)"

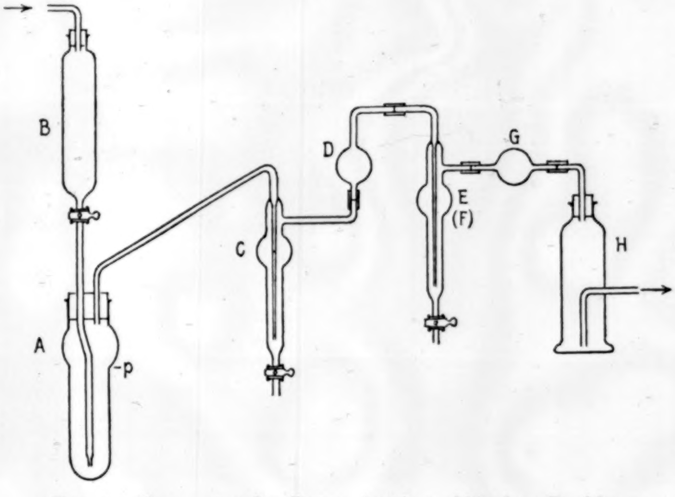

Fig. 2.—Apparatus for Determination of Carbon Residue.

Under "Determination of Carbon Dioxide" insert an alternative method to read as follows:

"*Alternative Method.*—The apparatus illustrated in Fig. 2, which is a modification of the usual form, may be used if desired. The principle of its operation is the same as that of the procedure described above.

"The apparatus consists of the following:

A tube, *A*, of decomposition of the sample.

A tube, *B*, to contain acid. A soda-lime tower is placed ahead of tube *B* so that air drawn through the apparatus is free of CO_2.

A "micro-drier," *C*, containing water, to act as a condenser and to retain most of the acid volatized from tube *A*.

A bulb, *D*, containing mossy zinc to remove the last traces of HCl.

A "micro-drier," *E*, containing H_2SO_4 to dry gases. If the sample evolves H_2S, another micro-drier, *F*, containing cadmium chloride solution is inserted between bulb *D* and micro-drier *E*.

A bulb, *G*, containing P_2O_5 to complete the drying of the gases.

A Midvale bulb, *H*, for absorption of CO_2. It is filled as follows: A layer of glass wool extending above the end of the outlet tube is placed in the bottom, and on this a layer of P_2O_5, about $\frac{3}{8}$ in. thick. Immediately on this is placed another layer of glass wool, and the rest of the bulb is filled with "Ascarite," except for a final layer of glass wool on the top.

"The manipulations are as follows: Sweep out tubes *C*, *D*, *E*, *F* and *G* with a current of CO_2-free air. Place in tube *B* sufficient HCl (sp. gr. 1.1) to completely decompose the sample, but so regulated in volume that the liquid level in tube *A* shall not be above the point *P*. Connect a soda-lime tower to the top of tube *B*.

"With limestone, use an 0.5-g. sample; with burned lime, hydrated lime, etc., use a 3 to 5-g. sample.

TABLE I.

Items	Affirmative	Negative	Not Voting
I. TENTATIVE STANDARDS TO BE ADVANCED TO STANDARD			
Tentative Specifications for Quicklime for Use in the Manufacture of Sulfite Pulp (C 46 - 25 T)	19	0	12
Tentative Specifications for Hydrated Lime for Use in the Manufacture of Varnish (C 47 - 22 T)	17	0	14
Tentative Specifications for Quicklime for Use in Water Treatment (C 53 - 25 T)	22	0	9
Tentative Specifications for Hydrated Lime for Use in Water Treatment (C 54 - 25 T)	21	1	9
Tentative Methods of Sampling, Inspection, Packing, and Marking of Quicklime and Lime Products (C 50 - 24 T)	23	0	8
II. REVISION OF TENTATIVE STANDARDS			
Tentative Methods of Chemical Analysis of Limestone, Quicklime and Hydrated Lime (C 25 - 26 T)	21	1	9
III. SPECIFICATIONS SUBMITTED AS TENTATIVE			
Tentative Specifications for Sand for Use in Lime Plaster	23	0	8

"Introduce rapidly into tube *A* a weighed amount (Note 1) of properly prepared sample, and immediately cover it with CO_2-free water and attach to the apparatus. Then attach the weighed Midvale bulb. Allow the acid from tube *B* to flow into tube *A*, the rate being governed by the rate of evolution of gas. Then gently heat tube *A*, and boil to expel all CO_2 (Note 21) while drawing a slow current of CO_2-free air through the apparatus. Continue the air current for three minutes after removing the flame. Disconnect the Midvale bulb and weigh it after it has come to equilibrium in the balance case. Use a second Midvale bulb as counterpoise in all weighings."

The sub-committee is continuing investigations to determine standard methods for measuring:

1. Sand carrying capacity of lime mortars;
2. Bulking properties of hydrated lime;
3. Rate of settling of milk of lime suspensions, and correlation of such data with industrial operations;

4. Fineness of particles of hydrated lime smaller than can be measured with a sieve;

5. Absorption of base plates for plasticimeter; and also,

6. The quantity of free lime in hydrated lime.

Committee C-7 recommends the approval by the Society of the several recommendations contained in this report listed in Table I, with the results of the letter ballot vote of the committee.

This report has been submitted to letter ballot of the committee, which consists of 31 members, of whom 24 have voted affirmatively, none negatively, and 7 have refrained from voting.

Respectfully submitted on behalf of the committee,

H. C. BERRY,
Chairman.

J. S. ELWELL,
Secretary.

EDITORIAL NOTE

The following tentative specifications and methods were approved at the annual meeting and subsequently adopted by letter ballot of the Society on September 1, 1927: for Quicklime for Use in the Manufacture of Sulfite Pulp; for Hydrated Lime for the Manufacture of Varnish; for Quicklime for Use in Water Treatment; for Hydrated Lime for Use in Water Treatment; and Methods of Sampling, Inspection, Packing and Marking of Quicklime and Lime Products. The specifications and methods appear in the 1927 Book of A.S.T.M. Standards, Part II.

The proposed revisions of the Tentative Methods of Chemical Analysis of Limestone, Quicklime and Hydrated Lime were accepted. The methods as revised appear on page 776.

The proposed Tentative Specifications for Sand for Use in Lime Plaster were accepted for publication as tentative and appear on page 774.

REPORT OF COMMITTEE C-8
ON
REFRACTORIES

Committee C-8 has held two general meetings during the year since the annual meeting of the Society in Atlantic City, in June. Both meetings of the committee were held in Detroit, the first in October concurrently with the meeting of the American Foundrymen's Association, and the second in February concurrently with the meeting of the American Ceramic Society.

The committee recommends for publication as tentative the following three proposed tentative specifications and the proposed tentative definitions of terms appended hereto.[1]

1. Tentative Specifications for Clay Fire Brick for Malleable Furnaces with Removable Bungs and for Annealing Ovens, printed as Appendix I to the annual report of Committee C-8 in 1926;
2. Tentative Specifications for Clay Fire Brick for Stationary Boiler Service;
3. Tentative Specifications for Clay Fire Brick for Marine Boiler Service;
4. Tentative Definitions of Terms Relating to Refractories.

Four of the series of six definitions proposed are recommended in order to clarify an existing confusion in terminology with particular reference to the fire clays from Missouri. The recent expansion and importance of that part of the refractories industry based on usage of diaspore and similar minerals from the Missouri district has caused the introduction into the trade of some terms which heretofore have been used in other producing districts with slightly different meanings and of necessity are here defined: namely, diaspore, nodular fire clay or burley, flint fire clay, and plastic or bond fire clay.

Two of the proposed definitions refer to properties of refractory materials. Because the terms "fusion point," "softening point," "deformation point," and "melting point" are sometimes used synonomously to mean the end point obtained upon heating a cone of a refractory material in accordance with the Standard Method of Test for Softening Point of Fire-Clay Brick (C 24 – 20) and sometimes to indicate different degrees of change of shape under heat treatment, the committee is recommending the use of the term "P. C. E." or "pyrometric cone equivalent," which will supplant the terms "fusion," "softening," "deformation," or "melting" when referring to the degree of bending obtained in the present standard softening point test referred to. The term "spalling" is defined to correct the prevailing conception in some circles that this phenomenon is concerned only with thermal shock. Actually, the committee has found a much wider use and understanding of the term "spalling" and recommends the rather lengthy proposed definition for this reason.

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[1] See pp. 810, 815, 822 and 839.—Ed.

The committee recommends revisions in one existing standard and one tentative standard, namely, the softening-point test and spalling test, as given below:

Standard Method of Test for Softening Point of Fire-Clay Brick (C 24 - 20).[1]—The following revisions are recommended for publication as tentative:

Section 4.—It is recommended that the angle of mounting of the cone be changed from 75 deg. to 82 deg.

Section 5 (a).—Change from its present form: namely,

> "The heating shall be done in a suitable furnace at a rate not greater than 15° C. (27° F.) per minute, nor less than 10° C. (18° F.) per minute after cone No. 1 is reached, or as nearly within these limits as possible."

to read as follows:

> "The heating shall be carried out in a suitable furnace at a rate to conform to the following requirements:

To reach cone 20	45 minutes
Time interval to cone 23	20 "
" " " " 26	6 "
" " " " 27	4 "
" " " " 28	4 "
" " " " 29	10 "
" " " " 30	4 "
" " " " 31	8 "
" " " " 32	4 "
" " " " 33	8 "
" " " " 34	18 "
" " " " 35	6 "

NOTE.—At 1000° C. the old cone pat may be removed and a new one put in without cooling the furnace down below red heat.

Considerable difficulty has been experienced in the past in obtaining satisfactory check determinations of the softening points of given materials when tested in laboratories using various types of equipment. Investigation has disclosed the fact that the rate of heating prescribed by the present A.S.T.M. procedure is so rapid that it cannot be followed except by the employment of apparatus heated electrically, or by the use of a gaseous fuel enriched with oxygen. When the prescribed rate is followed, it is difficult at times to make accurate determinations of the end points of the standard and test cones, since a number of the intervals are as short as one minute between consecutive Orton cones. In view of this, and the fact that the majority of softening point tests are conducted in gas-fired furnaces at present, which are not able to follow this high rate of heating, the revision recommended above has been proposed. The present procedure employs a uniform rate of heating from room to maximum temperature. Inasmuch as the effective temperature range is from cone 20 up, it is proposed that temperatures below cone 20 be reached in a comparatively short time and longer time be devoted to the range in which determinations are made. This emphasizes somewhat the time factor in this upper range which has not heretofore been given sufficient consideration in this test. It has been found that the rate of heating which is most suitable for gas-fired furnaces, and which has been used in the past, is approximately 150° C. per hour. Accordingly, this rate of heating is proposed for the range between cone 20 and the maximum.

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[1] 1924 Book of A.S.T.M. Standards.

Another important reason for altering the heating schedule is the fact that heretofore there has not been a cone end point temperature table of accepted accuracy and authority which could be used with the rate of heating prescribed by the present A.S.T.M. procedure. There is now available through the work of the U. S. Bureau of Standards,[1] an accurate table giving the cone end point temperatures for the rate of heating of 100° C. per hour. This investigation by the Bureau shows that great difference is not to be expected in the end points between the rate of heating of 150° C. per hour and 100° C. per hour. Consequently, end points as determined by the proposed procedure can be taken from the Bureau's table. Changing the angle of the cones from 75 deg. to 82 deg. is recommended to make this phase of the test also concur with work of the Bureau of Standards.

Tentative Method of Test for Resistance of Fire-Clay Brick to Spalling Action (*C 38 - 26 T*).[2]—The following revisions are recommended:

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[1] Paper by Fairchild, *Journal*, Am. Ceramic Society, Vol. 9, No. 11, pp. 701–743 (1926).

[2] *Proceedings*, Am. Soc. Testing Mats., Vol. 26, Part I, p. 784 (1926); also 1926 Book of A.S.T.M. Tentative Standards, p. 308.

Title.—Change to read as follows by the insertion of the word "thermal":

> "Tentative Method of Test for Resistance of Fire-Clay Brick to *Thermal* Spalling Action."

Section 3.—Change the last sentence of Paragraph (*a*) to read as follows by the addition of the italicized words and figure and the omission of the words in brackets:

> "The alternate heating and cooling shall be continued in hourly cycles until [the end of the brick spalls off] *a loss of 20 per cent by weight has occurred in each brick.*"

Omit Paragraph (*c*) reading as follows:

> "As an alternate for water dipping, air cooling may be used. This method should be used where the spalling is too rapid to get comparative results by the water dipping method. In this case the hot end of the brick shall be placed facing the air blast, 4 in. from the end of a 2-in. pipe from a ½-h. p. blower, delivering between 28 and 30 cu. ft. of air per minute."

Section 4.—Change from its present form: namely,

> "The report shall show the number of dips before loss started, the percentage of loss after each cooling, the total number of dips and the final percentage of loss by weight."

to read as follows:

> "The report shall show for each brick the number of dips before loss started, the percentage of loss after each cooling and the total number of dips until a loss of 20 per cent by weight has occurred."

The word "thermal" is inserted in the title to distinguish the type of spalling in this test from mechanical and structural spalling, in view of recently proposed nomenclature for refractories. Extensive experimental work has shown that the test should be conducted until considerable of the brick has spalled, since consistent results are not obtained by continuing the test merely "until the end of the brick spalls off." For this reason, and to supply numerical value for the test results, the recommendations are made to conduct the test until 20 per cent of the brick has spalled.

Deletion of the alternative spalling procedure, which makes use of cooling by air, is recommended, in view of the great expense of conducting such a test and the lack of definite information to indicate the correlation of data so obtained with life in service. Withdrawing this test method does not necessarily mean that employment of air-cooling for thermal spalling is not to be desired, but only that at the present time there is not sufficient information available regarding a suitable procedure.

The cooperative investigation with the Bureau of Standards for the preparation of standard samples of burned high-aluminous materials was completed during the year, and the Bureau now has available for distribution three samples of certified analysis. The committee will, however, continue independently a phase of the investigation to develop a method of chemical analysis for this particular type of material to differ somewhat from the present method as now used on materials composed of fire clay of only normal alumina content.

The growing need for a test to furnish a quantitative measure of the resistance of refractories to abrasion has occasioned the committee to make a very thorough and extensive review of the whole situation during the past year. As a result, all the work of previous investigations has been summarized and after a critical perusal of this data, having in view especially the factors influencing abrasion, a study of the sand-blast method to be conducted at elevated temperatures has been arranged to be carried out in the laboratories of a prominent consumer.

Because the present reheating test for linear contraction or expansion does not furnish results which are always consistent with actual service conditions, the committee has felt the necessity of a modified test. During the past year Mr. S. M. Phelps of the American Refractories Institute has investigated a great number of commercial brands of refractories for this test. A new test giving an index to the behavior of refractories under long heat treatment to supersede the present test, will be evolved.

The committee has felt that a spalling test dependent upon a determination of such fundamental properties of refractory materials as the thermal dilatation and the coefficient of elasticity, or a test which more closely simulates actual treatment of brick in service, is necessary. The tentative 2-in. water dipping test with no pre-heating, is felt to be more satisfactory than the older 4-in. water dipping test with pre-heating of the samples, but even the newer test does not predict accurately how a brick will work in service. It is recognized that the 850° C. water dipping test of the Bureau of Standards and the air spalling test of a certain large consumer have much to recommend them. An investigation of a simulative test has been in progress during the past year by Mr. Phelps on which very favorable progress has been made. The equipment and test procedure have been worked out and only a quantitative index to the loss the brick suffer in the test remains yet to be developed.

A critical report of the Fire-Clay Brick Specifications of the American Marine Standards Committee was made by Committee C-8 as a whole during the year. The cooperation of Committee C-8 was solicited in this matter to guide the representative of the Society acting in an advisory capacity on the Executive Board of the American Marine Standards Committee.

The recommendations appearing in this report have been submitted to letter ballot of the committee, with the following results:

Items	Affirmative	Negative	Not Voting
NEW TENTATIVE STANDARDS			
1. Tentative Specifications for Clay Fire Brick for Malleable Furnaces with Removable Bungs and for Annealing Ovens	28	0	5
2. Tentative Specifications for Clay Fire Brick for Stationary Boiler Service	28	1	4
3. Tentative Specifications for Clay Fire Brick for Marine Boiler Service	27	2	4
4. Tentative Definitions of Terms Relating to Refractories	29	0	4
REVISION OF STANDARD METHOD			
5. Standard Method of Test for Softening Point of Fire-Clay Brick (C 24 – 20)	27	2	4
REVISION OF TENTATIVE METHOD			
6. Tentative Method of Test for Resistance of Fire-Clay Brick to Spalling Action (C 38 – 26 T)	30	0	3

This report has been submitted to letter ballot of the committee, which consists of 35 members, of whom 29 have voted affirmatively, none negatively, and 6 have refrained from voting.

Respectfully submitted on behalf of the committee,

G. A. BOLE,
Chairman.

L. J. TROSTEL,
Secretary.

EDITORIAL NOTE

The proposed Tentative Specifications for Clay Fire Brick for Malleable Furnaces with Removable Bungs and for Annealing Ovens; for Clay Fire Brick for Stationary Boiler Service; for Clay Fire Brick for Marine Boiler Service; and the Definitions of Terms Relating to Refractories, were accepted for publication as tentative and appear on pages 810, 815, 822 and 839 respectively.

The proposed revisions of the Standard Method of Test for Softening Point of Fire-Clay Brick were accepted for publication as tentative and appear on page 1094.

The proposed revisions of the Tentative Method of Test for Resistance of Fire-Clay Brick to Spalling Action were accepted for publication as tentative. The method as revised appears on page 837.

REPORT OF COMMITTEE C-9
ON
CONCRETE AND CONCRETE AGGREGATES

During the past year Committee C-9 has endeavored to put into condition for report several matters which have been under consideration by its sub-committees for a number of years. In this the committee has been partially successful, with the result that these matters are being presented by the appropriate sub-committees as mentioned below.

SUB-COMMITTEE IV ON DESIGN OF CONCRETE MIXTURES

To Sub-Committee IV on Design of Concrete Mixtures, R. B Young, chairman, has been assigned the following specific duties.

1. To review the principal theories of design now advanced, and to prepare a statement of the conditions under which they apply.

2. To develop an adequate theory for the design of concrete mixes.

The sub-committee has completed the first of these assignments and as a result presents a review of the theories of designing concrete mixtures, which forms part of this report.

As mentioned in last year's report, the sub-committee through Prof. M. O. Withey arranged with Messrs. R. A. Nelson and B. F. Smith, Senior students at the University of Wisconsin, to make an analytical study of Series 201. The resulting report has been summarized by Mr. Nelson in the form of a paper which is submitted as Appendix I to this report.

It should be explained that the test series known as Series 201 is a group of tests made for the committee by a number of cooperating laboratories, for the purpose of determining the effect of size and grading of aggregate, and of variations in the quantities of cement and water on the strength and other properties of concrete.

This report has been unanimously approved by the sub-committee.

SUB-COMMITTEE V ON SPECIFICATIONS AND METHODS OF TESTS OF AGGREGATES

To Sub-Committee V on Specifications and Methods of Tests of Aggregates, H. F. Clemmer, chairman, three problems were assigned for study this year: namely, soundness of aggregates; abrasion of aggregates; and weights of materials. Later this sub-committee was also requested to present simple methods suitable for use in the field for quick determination of surface moisture, voids in inundated aggregate, and approximate apparent specific gravity of fine aggregate.

Soundness of Aggregates:

From replies to questionnaires submitted to members of this subcommittee the following information has been compiled by A. E. Stoddard, in charge of this study.

Present Status.—The Sodium Sulfate Soundness Test as outlined by *Bulletin 1216* of the U. S. Department of Agriculture, is being used by many offices charged with passing upon the suitability of materials for use as coarse aggregate in concrete. Usually it is applied only to crushed stone but in some cases it is also used on natural gravels.

In general it does not affect igneous rocks whose structure is visibly sound. Its action on sedimentary rocks is more varied, being most destructive with shales, argilaceous limestones, and soft sandstones.

Relation to Durability.—The main difficulty with the test is in the interpretation of the results in terms of resistance of the particles to the action of the weather. The general opinion of the results obtained is that they are of negative value. That is, stones passing the test appear to be satisfactory but those which fail in the test must be further examined to determine their durability. Usually this is done by examination of exposed faces of deposit when these are available, or by extended freezing and thawing tests.

Several laboratories are already attempting to determine the relation between the sodium sulfate test and freezing and thawing. Not all of these have furnished useful information but the data collected indicate that the Sodium Sulfate Soundness Test is somewhat erratic in its results. In many cases stone deposits which have long been used as a source of aggregates for concrete with apparent satisfaction have shown considerable disintegration in this test, while at the same time they have shown very little disintegration in freezing and thawing. Likewise, stones which have shown considerable disintegration in the Sodium Sulfate Soundness Test have shown no reduction in the compressive strength when concrete made with these aggregates was subjected to 90 alternations of freezing and thawing. Also, no disintegration was apparent when concrete made with these aggregates which showed unsoundness was subjected to 25 alternations of freezing and thawing.

Operation of the Test.—The results obtained with the Sodium Sulfate Soundness Test appear to be affected by several factors. The usual procedure calls for a saturated solution. The concentration of a saturated solution will vary with the temperature, reaching a maximum at 90.3° F. Merely maintaining an excess of the salt will not give uniform concentration without control of the temperature.

There are three forms of sodium sulfate salt, (*a*) anhydrous, (*b*) crystals containing 7 molecules of water, and (*c*) crystals containing 10 molecules of water. The form which the salt takes depends largely upon the temperature at which it is crystallized. The drying of the specimens at a temperature above 100° F. would remove the water of crystallization, leaving the anhydrous salt. This variation of the form of the salt would not affect the concentration of the solution but might affect the disintegrating effect of the salt by variation in the form of the crystal formed within the aggregate.

The measurement of the result of the test is based upon visual examination of the specimen. Such results are always open to criticism, in that they are subject to differences of opinion. Some investigators have tried to obtain a definite evaluation of this result by (*a*) determination of the loss in weight retained on a sieve of given mesh, (*b*) by the decrease of fineness modulus, and (*c*) by the effect on abrasion loss of the sample. All of these methods are complicated to some extent by the presence of the salt in the specimens after test. One investigator also claims that the salt acts on some rocks such as argilaceous limestones and aids in their disintegration by chemical reaction.

Future Investigation.—Possible lines of investigation appear to be:

1. To determine whether or not there is chemical reaction within the test piece. This could be determined by analysis of the sample and the solution after the test.

2. To determine the effect of recrystallization of the salt within the specimens to other forms. This could be accomplished by soaking the samples in fresh water for 20 hours after the second and fifth drying periods and noting the effect. This sort of crystallization would perhaps more nearly represent the action occurring in natural freezing and thawing.

3. To devise suitable quantitative measurement of the result of the test. This could be accomplished by one of the ways which have already been tried, probably best by the determination of fineness modulus of a 3000 or 5000-g. sample.

4. To determine the relation of the test to actual freezing and thawing, possibly by the relative effect of the two tests on some other physical property such as compressive strength, toughness, hardness, or abrasion.

The data from extensive investigations now under way in the U. S. Bureau of Public Roads and several State Highway Departments should, when available, afford information which will permit of definite recommendations by this committee.

Abrasion of Aggregates:

A study is being made of the data available so that a definite outline of work may be presented to the sub-committee.

Weights of Materials:

A very large amount of data has been obtained and tabulated by Mr. Fred Hubbard, in charge of the study on weights of material, but there are so many data still available that the sub-committee recommends deferring a report on this problem until a complete report may be made.

Methods for Determination of Moisture Content, Voids, and Specific Gravity of Fine Aggregate in the Field:

Mr. Cloyd M. Chapman has offered the following methods of tests, and on the recommendation of Sub-Committee V they are submitted herewith with the recommendation that they be accepted for publication as tentative as appended hereto.[1] They are for field determination of (*a*) Approximate Percentage of Voids in Fine Aggregate, (*b*) Approximate Apparent Specific Gravity of Fine Aggregate, and (*c*) Surface Moisture in Fine Aggregate.

These tests are of a simple type which may be quickly and conveniently performed on the job. The only apparatus required for making all their determinations is a pan balance of one or two kilograms capacity and a special flask designed by Mr. Chapman and now available from several manufacturers.

There has been a growing need for a simple, rapid field test for percentage of moisture in fine aggregate. This need has been stimulated by the increasing realization of the necessity for controlling accurately the amount of water entering into each batch of concrete. To know with accuracy the amount of water present it is necessary, when damp volume or weight measurement is used, to know the amount or percentage of surface moisture in the fine aggregate. The method commonly employed in making determinations of moisture in the past has been that of weighing a sample of the damp aggregate, drying it in an oven to constant weight, again weighing, and, from the loss in weight, computing the percentage of moisture in the aggregate. This method is open to two criticisms: First, it is slow, requiring an hour or more for its completion; and, second, it determines the total free moisture in the aggregate which in turn necessitates making an allowance for moisture that will be absorbed by the aggregate when computing the correct amount of water to be added to the batch to secure the desired water-cement ratio. With the proposed tentative method a sample of the damp aggregate is weighed and inserted in a special calibrated flask containing an accurately measured quantity of water. The increase in volume resulting from the introduction of the sample into the flask is noted, and by means of a formula or by the use of a suitable chart, the percentage of surface moisture in the fine aggregate is ascertained. The method is based on the assumption that the apparent specific gravity of different samples of aggregate does not vary to any considerable degree. Since it is based on a volume determination it takes into account only the moisture on the surface of the particles and neglects the absorbed moisture, which is just what is desired for the purpose for which this test is to be used. The principles underlying the test have been applied before in other forms of apparatus and have been found to give satisfactory results. Several of the special flasks have been used by members of the committee and have been found useful and convenient in field work. During the coming year, the committee proposes to conduct a series of tests to ascertain more exactly the probable error and the accuracy attainable in the field with this method.

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[1] See pp. 797, 794 and 800.—ED.

The second tentative method of test offered for approval and trial is for the determination of voids in fine aggregate when inundated. This, too, is a matter which has rapidly come to the front in recent years, or since the application of the inundation method to the measurement of batches of fine aggregate. The use of the inundation method gives a fairly accurate and uniform measure of the quantity of fine aggregate in each batch but the amount of water present in each batch depends upon the percentage of voids in the fine aggregate being measured. The total volume of voids varies with the grading of the aggregate. They may be less than 25 per cent of the gross volume or over 40 per cent with the same kind of aggregate, depending upon the grading. If a fine aggregate being measured on a job by the inundation method is assumed in computing water-cement ratio to have 30 per cent of voids, then each 3 cu. ft. would hold 6¾ gal. of water. If these 3 cu. ft. of fine aggregate with the $6\frac{3}{4}$ gal. of water were added, together with a suitable amount of coarse aggregate, to a bag of cement there might result a concrete having a compressive strength, according to Abrams' data, of about 2300 lb. per sq. in. Now, if due to changes in grading, this aggregate contained 35 per cent of voids, then the water in 3 cu. ft. of inundated aggregate would be $7\frac{7}{8}$ gal. and the corresponding strength would be about 1600 lb. per sq. in., or a loss of 700 lb. in strength due to an increase of 5 per cent in the voids. The figures given in this case may be somewhat above the average for variation of voids in localities where uniform or well-prepared aggregates are available, but in many localities even greater variations than these will frequently be encountered. It is therefore necessary, if the water-cement ratio is to be under control, to detect and correct for changes in the voids in fine aggregate which is measured in an inundated state. To make a determination of voids by the proposed tentative method, it is only necessary to weigh a definite volume of inundated aggregate whose apparent specific gravity is known or has been previously determined. From the ascertained weight and the known apparent specific gravity, the percentage of voids may be computed by formula or determined by means of a chart or curve.

The third method of test offered for approval as tentative is one for the field determination of approximate apparent specific gravity of fine aggregates. The term "approximate apparent specific gravity" may at first seem unnecessarily long, but since the physical constant determined by following the method proposed does not give either the specific gravity or apparent specific gravity or bulk specific gravity as defined by the Society, it seems necessary to describe it by another term.

The condition of the sample of fine aggregate used for the test is such that the pores of the individual particles contain moisture. The sample of fine aggregate is dried only to the extent that the surface moisture is evaporated and the aggregate is free flowing but the moisture within the particles is still retained. A specific gravity determination made on a material in this condition would not give the same result as one made on a dry sample and for this reason a distinctive name should be applied.

The results of determinations of specific gravity made by the proposed method are useful chiefly in making determinations of voids and surface moisture by the two other proposed methods submitted with this report. And all three of these methods have for their object the simplifying and shortening of the field procedure where the water-cement ratio method of controlling concrete mixes is in use.

SUB-COMMITTEE VI ON SPECIFICATIONS FOR CONCRETE

Sub-Committee VI on Specifications for Concrete, Mr. Sanford E. Thompson, chairman, has been studying the matter of concrete specifications, giving particular attention to that phase which has to do with proportioning. The 1924 report of the Joint Committee on Standard Specifications for Concrete and Reinforced Concrete[1] has formed the basis for the work of this sub-committee and there has been prepared a Recommended Revision of Section *A* of Chapter V on Proportioning and Mixing Concrete, which revision appears as Appendix II to this report.

This proposed revision introduces the maximum water content method of control which has become so well recognized as the correct basis for regulating or controlling the strength of concrete. The report of the Joint Committee specifies two methods of proportioning: (1) a mix predetermined by laboratory tests using the materials which are to be used on the job, and (2) a mix based on the size and fineness modulus of the aggregate and selected with the aid of tables which form a part of the report. It contains no provision for the use of the water-cement ratio or what this sub-committee has termed the "Maximum Water Content" Method of Design and Control.

The new specifications are unusual in introducing a water requirement for certain values of modulus of rupture rather than for compressive strength alone. This was considered necessary to make the specifications of full value for road work.

The sub-committee feels that at present there are still many reasons for not discarding entirely the arbitrary proportioning method and therefore has retained it, leaving to the engineer the choice for each particular job. Several clauses in regard to the allowance to be made for bulking have been added to make this method more workable.

This sub-committee is of the opinion that the concrete industry is greatly in need of a simple and practical method of applying the recently developed principles of concrete strength control and recommends the revision of Chapter V of the Joint Committee Report along the lines suggested in Appendix II to this report. Concrete can never attain its rightful position as a structural material until control of quality is practiced so universally as to permit the most economical composition along with complete knowledge of the quality in each structure.

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 24, Part I, p. 303 (1924).

SUB-COMMITTEE X ON CONDITIONS AFFECTING THE DURABILITY OF CONCRETE

Sub-Committee X on Conditions Affecting the Durability of Concrete, Mr. P. J. Freeman, chairman, presents a report in which attention is called to some of the factors entering into the problem of durability. The report is appended hereto. Through the efforts of this sub-committee, Mr. G. F. Loughlin, geologist in the Bureau of Mines, is preparing a paper dealing with the geological aspects of concrete with special reference to durability.

SUB-COMMITTEE XII, EDITORIAL COMMITTEE

Sub-Committee XII, Editorial Committee, Mr. A. T. Goldbeck, chairman, has carefully edited all of the Standards and Tentative Standards under the jurisdiction of Committee C-9 and has proposed many revisions therein. Its report is appended hereto.

TABLE I.

Items	Affirmative	Negative	Not Voting
I. NEW TENTATIVE METHODS			
1. Method of Test for Approximate Percentage of Voids in Fine Aggregate	45	0	17
2 Method of Test for Approximate Apparent Specific Gravity of Fine Aggregate	45	0	17
3. Method of Test for Surface Moisture in Fine Aggregate	44	0	18
II. REVISIONS IN EXISTING STANDARDS			
4. Standard Method of Making and Storing Specimens of Concrete in the Field (C 31 - 21)	43	1	18
5. Standard Method of Test for Organic Impurities in Sands for Concrete (C 40 - 22)	44	0	18
6. Standard Method of Test for Unit Weight of Aggregate for Concrete (C 29 - 21)	45	0	17
7. Standard Methods of Making Compression Tests of Concrete (C 39 - 25)	45	0	17
III. ADVANCEMENT TO STANDARD OF TENTATIVE METHODS			
8 Methods of Securing Specimens of Hardened Concrete from the Structure (C 42 - 25 T)	46	0	16

The sub-committee has proposed editorial changes in all of the standards under the jurisdiction of Committee C-9 and has proposed changes in substance in four of them:

Standard Methods of Making and Storing Specimens of Concrete in the Field (C 31 - 21);
Standard Method of Test for Organic Impurities in Sands for Concrete (C 40 - 22);
Standard Method of Test for Unit Weight of Aggregate for Concrete (C 29 - 21);
Standard Methods of Making Compression Tests of Concrete (C 39 - 25).

Since these revisions are being submitted for the first time and are being recommended to go into effect immediately, Committee C-9 asks for the necessary nine-tenths vote.

In addition it is recommended that the Tentative Methods of Securing Specimens of Hardened Concrete from the Structure (C 42 - 25 T)[1] be advanced to standard incorporating the editorial revision proposed by the sub-committee.

These several recommendations as well as the submission of the three new tentative methods, have been submitted to letter ballot of the committee with the result given in Table I.

This report has been submitted to letter ballot of the committee, which consists of 62 members, of whom 46 have voted affirmatively, one negatively and 15 have refrained from voting.

Respectfully submitted on behalf of the committee,

CLOYD M. CHAPMAN,
Chairman.

STANTON WALKER,
Secretary.

EDITORIAL NOTE

The proposed revisions of the Standard Method of Making and Storing Specimens of Concrete in the Field; Method of Test for Organic Impurities in Sands for Concrete; Method of Test for Unit Weight of Aggregate for Concrete; and Methods of Making Compression Tests of Concrete, were approved at the annual meeting by a nine-tenths vote and subsequently adopted by letter ballot of the Society on September 1, 1927. The methods as revised appear in the 1927 Book of A.S.T.M. Standards, Part II.

The Tentative Methods of Securing Specimens of Hardened Concrete from the Structure were approved at the annual meeting and subsequently adopted by letter ballot of the Society on September 1, 1927. The methods appear in the 1927 Book of A.S.T.M. Standards, Part II.

The proposed Tentative Method of Test for Approximate Percentage of Voids in Fine Aggregate; Test for Approximate Apparent Specific Gravity of Fine Aggregate; and Test for Surface Moisture in Fine Aggregate, were accepted for publication as tentative and appear on pages 797, 794 and 800, respectively.

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 25, Part I, p. 631; also 1926 Book of A.S.T.M. Tentative Standards, p. 310.

REPORT OF SUB-COMMITTEE IV ON DESIGN OF CONCRETE

A REVIEW OF THE THEORIES OF DESIGNING CONCRETE MIXTURES

This report deals with the design of concrete for compressive strength, since compressive strength is commonly accepted as the principal measure of the quality of a concrete. However, the subcommittee is not prepared to accept this view and will point out that whereas, broadly speaking, the compressive strength of concrete bears a rough relationship to its other mechanical properties, such as resistance to abrasion, transverse and tensile strength, elasticity, permeability and absorption, yet concretes of satisfactory compressive strength do not always possess these properties to the degree desired for a particular purpose. Furthermore, concrete of satisfactory compressive strength may lack durability when exposed to weathering or fire; or it may be permeable and highly absorptive.

The strength of concrete made from sound durable material depends upon:

(*a*) The extent to which the solid particles are glued or bonded together;

(*b*) The actual amounts of solid material in the concrete.[1]

Assuming a given set of aggregates and the same conditions of fabrication, two of the most important factors which affect the bond between particles are:

1. The proportion of cement in a given quantity of concrete.
2. The amount of mixing water.

Under ordinary conditions of mixing and placing, the actual amounts of solid material in the concrete depend primarily upon the quantity of mixing water present and to a lesser extent upon the entrained air which in turn depends upon the type of mixing equipment used. It will be affected also by the amount of work done upon the concrete, but with plastic mixes and the usual methods and equipment, the influence of the work done is small.

Water:

The mixing water not only influences the quality of the bond between the particles and the density of the concrete, but, if in excess, it has deleterious effects other than these on the cement. One such deleterious effect is in the formation of laitance.

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[1] The ratio of the actual or absolute volume of the solid particles to the volume of the concrete is properly termed the "solidity ratio" often called, though less exactly, the "density."

Cement:

From the above, it follows that the gluing action of the cement will be in direct proportion to the amount of cement in the concrete. Again, existing data supports this theory of mixtures and the expressions thus far formulated for the variation in the strength of concrete are in conformity with it.

These theories have been variously expressed by different investigators. There are those that deal with the inter-relations of the absolute volumes of cement, aggregates and voids,[1] for example the relation of the strength to the void-cement ratio and the relation of strength to the space-cement ratio and there is the relation between strength and the water-cement ratio.[2]

Space-Cement-Strength Relationship:

In the first group of expressions the measure of the bonding effect of the cement is taken as directly proportional to the quantity of cement present, expressed as c and the effect of the proportion of solids is measured either by means of the voids, v, or by means of the space, $v + c$.[3]

The available data show that the relation between strength and space-cement ratio or void-cement ratio is affected by the amount of water used. Talbot and Richart show that this effect can be measured by means of the relative water content, which is defined by them as being the ratio of the amount of water used to that amount which would yield the smallest volume of mortar when mixed with cement and fine aggregate in the proportions under consideration (they call this the "basic" water content).

Water-Cement Ratio Relationship:

In the water-cement ratio relationship again the proportion of cement, c, is used as a measure of the bonding effect, but in this case, the quantity of water, *w*, is used not only as a measure of the effect of the solids present but in addition as a measure of the effect of water upon the bonding or gluing action of the cement.

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[1] This type of expression was originated by Feret and has been further developed by Fuller and Thompson, Talbot and Richart, Crum and others:

R. Feret, *Bulletin* de la Société d'Encouragement pour l'Industrie Nationale, 1897, Vol. II, p. 1604; *Revue de l'Ingenieur*, September, 1923.

W. B. Fuller and S. E. Thompson, "The Laws of Proportioning Concrete," *Transactions*, Am. Soc. Civil Engrs, Vol. LIX, p. 67, 1907.

R. W. Crum, "Method of Proportioning Concrete Materials, Screened and Unscreened Gravels," *Bulletin No. 60*, Iowa State College, Ames, Iowa.

A. N. Talbot and F. E. Richart, "The Strength of Concrete; Its Relation to the Cement, Aggregates and Water," *Bulletin No. 137*, University of Illinois, Urbana, Ill.

[2] D. A. Abrams, "Design of Concrete Mixtures," *Bulletin No. 1*, Structural Materials Research Laboratory, Lewis Institute, Chicago, Ill.; "Design and Control of Concrete," 1927 Edition, Portland Cement Association, Chicago, Ill.

[3] Here c = absolute volume of cement in a unit volume of concrete, and
v = volume of voids in a unit volume of concrete.

The truth of the relation of the strength to the water-cement ratio is well established by the data of Abrams,[1] Talbot and Richart,[2] Young,[3] Graf,[4] and the cooperative tests, Series 201, sponsored by this sub-committee,[5] an analysis of which has been prepared by R. A. Nelson to accompany this report and appearing in Appendix I.

Utilization:

Mixtures can be correctly designed by either the use of the relationship between strength and the space-cement ratio, strength and the void-cement ratio, or strength and the water-cement ratio as is exmplified in the paper by R. W. Crum being presented at this annual meeting of the Society.[6] Methods based on space or voids-cement ratio, as developed by Talbot and Richart seem to be the most precise statement of the fundamental concepts, but to date those who have utilized these theories in designing mixtures for strength have very generally adopted the water-cement ratio as it has been found simple in application and to give results of sufficient accuracy.

Designing by the Water-Cement Ratio Method:

The methods followed by different users of the water-cement ratio theory vary in the details of their application and it is the intention of the sub-committee to consider the procedure at some length in a later report. For the present the steps involved are only being outlined very briefly, as follows:

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[1] D. A. Abrams, "Design of Concrete Mixtures," *Bulletin No. 1*, Structural Materials Research Laboratory, Lewis Institute, Chicago, Ill. Similar water-cement ratio strength curves are to be found in Abrams' many articles, as for instance:

"Effect of Fineness of Cement," *Proceedings*, Am. Soc. Testing Mats., Vol. XIX, Part II, p. 328 (1919).

"Effect of Tannic Acid on the Strength of Concrete," *Proceedings*, Am. Soc. Testing Mats., Vol. XX, Part I, p. 309 (1920).

"Calcium Chloride as an Admixture in Concrete," *Proceedings*, Am. Soc. Testing Mats., Vol. 24, Part II, p. 781 (1924).

[2] A. N. Talbot and F. E. Richart, "The Strength of Concrete: Its Relation to the Cement, Aggregates and Water," *Bulletin No. 137*, University of Illinois, Urbana, Ill.

[3] R. B. Young, "Analysis of Concrete Proportioning Theories," *Canadian Engineer*, November 27, 1919. Similar data are to be found in other articles by Mr. Young, among which are:

"New Methods of Proportioning Concrete in Theory and Practice," *Journal*, Boston Soc. Civil Engrs., Vol. 8, March, 1921.

"Producing Concrete of Uniform Quality," *Proceedings*, Am. Soc. Civil Engrs., Vol. LII, September, 1926.

[4] O. Graf, "Proper Proportioning of Concrete and Predetermination of Its Compressive Strength at Place of Construction," *Gesundheits-Ingenieur*, Vol. 46, p. 243, June 30, 1923.

[5] *Proceedings*, Am. Soc. Testing Mats., Vol. 22, Part I, p. 329 (1922).

[6] R. W. Crum, "Proportioning of Concrete," *Proceedings*, Am. Soc. Testing Mats., Vol. 27, Part II, p. 337 (1927).

1. Selection of the cement, aggregate and water. This will involve a study of the materials available and a consideration of their quality and the cost of concrete made from them. On large or important work this study may require that steps 3 and 4 be carried out for more than one cement and aggregate.

2. Selection of the strength for which to design.

NOTE.—In the design of mixtures, especially those to be used where severe climatic conditions exist, other qualities beside strength must be given careful consideration.

3. Determination of the water-cement ratio applicable to the materials selected.

4. Determination of the proper proportions of fine and coarse aggregate to give the desired workability for the given water-cement ratio.

5. The conversion of the proportions determined into field units, a process to be repeated when necessary to take care of varying field conditions such as changes in the grading or moisture of the aggregates as received.

The committee wishes to point out that the proper designing of a mixture does not insure good concrete but must be followed by sufficient supervision to make certain that the concrete is properly made, placed and cured. The extent of the supervision necessary will vary with circumstances but must be provided in some degree if the benefits that can be derived from designed concrete mixtures are to be realized.

Respectfully submitted on behalf of the sub-committee,

R. B. YOUNG,
Chairman.

REPORT OF SUB-COMMITTEE X ON CONDITIONS AFFECTING THE DURABILITY OF CONCRETE

The members of Sub-Committee X have examined many examples of concrete which showed signs of either partial or complete disintegration. In most cases the cause of the deterioration could readily be traced to improper use, rather than to defective materials. Some of the violations of ordinary good practice were obvious and well known.

In general the unsatisfactory conditions observed were caused by porous concrete which resulted from one or more of the following:

1. Excess of mixing water;
2. Deficiency of cement;
3. Dirt or an excess of fine material in the aggregate;
4. Segregation of materials in handling and placing the freshly mixed concrete.

Anything which causes concrete to be permeable should be avoided as the action of freezing and thawing will ultimately find the bad places and expose them to view. Many retaining walls have disintegrated because of lack of drainage. Water accumulates back of the wall and percolates through the concrete. It might be satisfactory to make an impermeable concrete wall but it is better to thoroughly drain back of the wall and thus avoid subjecting the concrete to a needless danger. If the water percolates through the wall, freezing and thawing will ultimately affect the durability of the concrete.

These conditions are more closely related to construction than to materials and a study of such conditions is being conducted by a Committee, of the American Concrete Institute, on Destructive Agents and Protective Treatments.[1]

Under certain conditions it has been found that lean mixes produce an unsound concrete whereas a somewhat richer mix produces a durable concrete under identical conditions; for example, a road base may disintegrate under brick or asphalt when the mix is as lean as 1:3:6 and be satisfactory on the same subgrade if the mix is 1:2½:5 or 1:2:4. Under such conditions, the concrete is not injured by percolating water but it appears that the quantity of cement is insufficient to maintain a normal condition for good concrete when one side is in contact with the damp subgrade and the other kept sealed from air. The immediate remedy seems to be to use the richer mixes under such conditions.

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[1] *Proceedings*, Am. Concrete Inst., Vol. XX, pp. 564–576 (1924); Vol. XXI, pp. 266–283 (1925); Vol. XXII, pp. 641–653 (1926).

Attention is called to a symposium[1] held under the auspices of Committee C-9 on What Properties of and Methods of Making Concrete Require Further Investigation. At this time examples of defective concrete were cited and the subject discussed at considerable length. Sub-Committee X has since been confining its studies more closely to the effects of materials on concrete rather than methods of mixing and placing.

The resistance of concrete to percolating water is intimately associated with the quality of the aggregate which in turn may affect the length of life of the concrete. The U. S. Bureau of Public Roads is conducting an elaborate series of tests on concrete specimens made from various kinds of aggregate selected from widely scattered localities. The purpose of these tests is to determine the comparative durability of aggregates when combined with different proportions of cement and sand. The concrete specimens are being subjected to alternate freezing and thawing over a long period of time. These tests have been under way for about 2 years but so far nothing definite can be reported except that the 1:3:6 concrete is beginning to show disintegration.

Other laboratories are also conducting research along these lines and an endeavor is being made to approximate the actual freezing and thawing conditions encountered by concrete in service. It will therefore take considerable time to obtain any reliable data. An examination of gravel concrete used with a 1:2:4 mix has indicated that under such conditions the concrete was sound after a number of years' exposure, whereas the same aggregates used in a 1:3:6 mix produced an unsound concrete and apparently some of the gravel disintegrated. A soundness test for gravel is needed which would indicate the durability of gravel in concrete.

Some limestones will disintegrate if used in concrete and examples of such structures are being studied. The sodium sulfate soundness test when applied to limestone appears to be on the side of safety, for no examples of disintegrated concrete have been brought to the sub-committee's attention where the unsound limestone could not have been detected by the sodium sulfate test. It may be found that five treatments are more severe than necessary to obtain a durable stone and this feature of the test is being investigated.

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 23, Part II, p. 156 (1923).

It is felt that a geological examination of the subject of unsound aggregate will be of service to the engineer and to that end the sub-committee has been fortunate enough to obtain the cooperation of Mr. G. F. Loughlin of the U. S. Geological Survey, who is preparing a paper giving the results of his study of rocks used in concrete structures which have disintegrated.

Respectfully submitted on behalf of the sub-committee,

P. J. Freeman,
Chairman.

REPORT OF SUB-COMMITTEE XII, EDITORIAL COMMITTEE

The Editorial Committee was appointed to review the present standards and tentative standards under the jurisdiction of Committee C-9 for the purpose of making editorial changes. Each member of the Editorial Committee suggested changes and on the basis of these suggestions a revised set of standards was proposed and sent to the entire membership of Committee C-9 for further criticism. Finally all suggestions were considered at the meeting of Committee C-9 held on March 17 and revisions of the standards are being recommended in accordance with the action of the committee.

The following standards and tentative standards were reviewed:

Standard Method of Test for Unit Weight of Aggregate for Concrete (C 29 - 21);

Standard Methods of Making and Storing Specimens of Concrete in the Field (C 31 - 21);

Standard Method of Test for Voids in Fine Aggregate for Concrete (C 30 - 22);

Standard Method of Test for Organic Impurities in Sands for Concrete (C 40 - 22);

Standard Method of Test for Sieve Analysis of Aggregates for Concrete (C 41 - 24);

Standard Methods of Making Compression Tests of Concrete (C 39 - 25);

Tentative Methods of Securing Specimens of Hardened Concrete from the Structure (C 42 - 25 T);

Tentative Specifications for Concrete Aggregates (C 33 - 26 T).

CHANGES OTHER THAN EDITORIAL

Many desirable changes in the standards not of an editorial nature were suggested by various members of Committee C-9 and these will be placed in the hands of all members of the committee so that they may be given full consideration by the proper sub-committee. For the present, however, only those changes which can be considered as editorial are being recommended in the standards, with four exceptions as follows:

Standard Methods of Making and Storing Specimens of Concrete in the Field (C 31 - 21).[1]—

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[1] 1924 Book of A.S.T.M. Standards.

Section 2.—Change to read as follows by the addition of the italicized words and the omission of those in brackets:

> "The test specimens shall be cylindrical in form with the length twice the diameter. [In general a mold whose diameter is not less than four times the diameter of the largest size aggregate shall be used. (The sizes most commonly used are 6 by 12-in. and 8 by 16-in. cylinders.)] *The standard shall be 6 by 12-in. cylinders where the coarse aggregates does not exceed 2 in. in size; for aggregates larger than 2 in., 8 by 16-in. cylinders shall be used; 2 by 4-in. cylinders may be used for mixtures without coarse aggregate.*"

The requirement of 6 by 12-in. cylinders for 2-in. size is a change in substance, not merely an editorial change, but is necessary to make it agree with the corresponding requirement Methods C 39 - 25. It is thought desirable to harmonize these standards by changing Methods C 31 as indicated.

Standard Method of Test for Organic Impurities in Sands for Concrete (C 40 - 22).[1]—This method is being completely rearranged but in addition an important change, not editorial, is recommended, namely, changing the quantity 22.5 cc. in Section 2 (*e*) to 97.5 cc. Also, omit the phrase "then 25 cc. of water added" at the end of this section.

Standard Method of Test for Unit Weight of Aggregate for Concrete (C 29 - 21).[1]—

Section 2 (*c*).—Change the diameter of rod specified from $\frac{3}{4}$ in. to $\frac{5}{8}$ in., and the length from 18 in. to 24 in., to harmonize with the corresponding requirements of Methods C 39 - 25.

Standard Methods of Making Compression Tests of Concrete (C 39 - 25).[2]—

Section 11 (*b*).—Change the requirement "6 seconds" in this section to "10 seconds."

CHANGES BOTH EDITORIAL AND IN SUBSTANCE RECOMMENDED IN STANDARDS AND TENTATIVE STANDARDS

Standard Method of Test for Unit Weight of Aggregate for Concrete (C 29 - 21).[1]—

Section 1.—Change from its present form: namely,

> "The unit weight of fine, coarse, or mixed aggregates for concrete shall be determined by the following method:"

to read as follows:

> "*Scope.*—The test covers the method for the determination of unit weight of fine, coarse, or mixed aggregates for concrete."

Section 2 (*c*).—Change the diameter of rod specified from $\frac{3}{4}$ in. to $\frac{5}{8}$ in., and the length from 18 in. to 24 in., to harmonize with the corresponding requirements of Methods C 39 - 25.

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[1] 1924 Book of A.S.T.M. Standards.

[2] A.S.T.M. Standards Adopted in 1925.

Section 3.—Insert the weight of water, namely, 62.355 lb.

Section 4.—Add a side heading "Condition of Sample."

Section 5.—Omit the last sentence in the second paragraph reading as follows:

> "No effort should be made to fill holes left by the rod when the aggregate is damp."

Other editorial changes in wording are recommended which do not change the meaning of the paragraph.

Standard Methods of Making and Storing Specimens of Concrete in the Field (C 31 - 21).[1]—

Section 2.—Change to read as follows by the addition of the italicized words and the omission of those in brackets:

> "The test specimens shall be cylindrical in form with the length twice the diameter. [In general a mold whose diameter is not less than four times the diameter of the largest size aggregate shall be used. (The sizes most commonly used are 6 by 12-in. and 8 by 16-in. cylinders.)] *The standard shall be 6 by 12-in. cylinders where the coarse aggregate does not exceed 2 in. in size; for aggregates larger than 2 in., 8 by 16-in. cylinders shall be used; 2 by 4-in. cylinders may be used for mixtures without coarse aggregate.*"

The requirement of 6 by 12-in. cylinders for 2 in. size is a change in substance, and not merely an editorial change, but is necessary to make it agree with Methods C 39 - 25.

Section 3.—In the second sentence of Paragraph (*b*) change the word "form" to "mold," and in the last sentence change the words "after being" to the word "when."

Section 4 (*b*).—Change the word "point" in the first sentence to "place." In the second sentence change the words "at that place" to "from a given place."

> *Figure 1.*—Change the note to this figure to read as follows:
>
> "*Stock:* 6½ in. O. D. cold-drawn seamless steel tubing. ¼-in. walls. Make narrow slit along one element with $\frac{1}{32}$ in. slitting saw. May also use 6 in. steel water-pipe, machined inside. Slit along one element, so that when closed will give 6 in. inside diameter."

Section 5.—In the second sentence of Paragraph (*a*) change the word "stirring" to "mixing."

Change Paragraph (*b*) to read as follows by the addition of the italicized words and the omission of those in brackets:

> "The test specimens shall be molded by placing the concrete in the [form] *mold* in layers approximately 4 in. in thickness. Each layer shall be puddled with 25 [to 30] strokes with a ⅝ [to ¾] in. [bar] *rod* [about 2 ft.] *24 in.* long, [tapered slightly] *bullet-pointed* at the lower end. After puddling the top layer, the surface concrete shall be struck off with a trowel and covered with the top cover plate which [will] *may* later be used in capping the test specimens."

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[1] 1924 Book of A.S.T.M. Standards.

Section 6.—Change to read as follows by the addition of the italicized words and the omission of those in brackets:

> "Two to four hours after molding, the test specimens shall be capped with a thin layer of stiff neat cement paste in order that the cylinder may present a smooth end for testing. The cap [can best] *shall* be formed by means of a piece of plate glass $\frac{1}{4}$ in. thick *or a machined metal plate* $\frac{1}{2}$*-in. thick* and of a diameter 2 or 3 in. larger than that of the mold. [This] *The* plate is worked on the fresh cement paste until it rests on top of the [form] *mold.* The cement for capping should be mixed to a stiff paste [some time] *2 to 4 hours* before it is to be used in order to avoid the tendency of the cap to shrink. Adhesion of the concrete to the top and bottom plates [can] *may* be avoided by oiling the plates or by inserting a sheet of paraffined [tissue] paper."

Section 7.—Change to read as follows by the addition of the italicized words and the omission of those in brackets:

> "At the end of 48 hours the test specimens shall be removed from the molds and buried in damp sand except in case the molds shown in Fig. 3 are used ; [in this case test specimens] *when they* may be buried in damp sand without *the* removal of the mold, thus permitting shipping [of the test specimens] in the molds."

Section 8 (b).—Change to read as follows by the addition of the italicized words and the omission of those in brackets:

> "Should a 7-day test be required, the test specimens shall remain at the [works] *work* as long as possible to harden and then shall be shipped so as to arrive at the laboratory in time [to make the] *for* test on the required date."

Add a new Paragraph (*c*) to read as follows:

> "Specimens shall be protected from drying after removal from damp storage and before testing."

Standard Method of Test for Voids in Fine Aggregate for Concrete (C 30 – 22).[1]—

Title.—Change to read as follows by the addition of the italicized words:

"Standard Method of Test for *Determination of* Voids in Fine Aggregate for Concrete."

Standard Method of Test for Organic Impurities in Sands for Concrete (C 40 – 22).[1]—This method is being completely rearranged, the more important changes being the following:

Section 1.—Omit the last sentence reading as follows:

> "Sands which produce a color in the sodium hydroxide solution darker than the standard color should be subjected to strength tests in mortar or concrete before use."

Section 2 (b).—Change to read as follows by the addition of the italicized word and the omission of the word in brackets:

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[1] 1924 Book of A.S.T.M. Standards.

"A 12-oz. graduated *clear* glass [prescription] bottle shall be filled to the 4½-oz. mark with the sand to be tested."

Section 2 (e).—Change the quantity 22.5 cc. in this section to 97.5 cc. Also, omit the phrase, "then 25 cc. of water added," at the end of this section.

Standard Method of Test for Sieve Analysis of Aggregates for Concrete (C 41 - 24).[1]—

Table I.—Add a column giving the micron equivalents. In the column headed "Average Opening" indicate that the permissible variations are plus or minus, to conform with the Standard Specifications for Sieves for Testing Purposes (E 11) of the American Society for Testing Materials.[2]

Section 2.—Change from its present form: namely,

"The sample shall be dried at not over 110° C. (230° F.) to constant weight."

to read as follows:

"The sample shall be dried to constant weight at a temperature not exceeding 110° C. (230° F.)."

Section 3.—Change the last word of Paragraph (*a*) from "sifting" to "sieving."

In Paragraph (*b*) change the words "be as given in" to "conform to."

Section 4 (a).—In the second sentence change the word "sifting" to "sieving" and the word "sample" to "residue."

Section 5 (b).—Add the micron equivalents for the designations of sieves.

Standard Methods of Making Compression Tests of Concrete (C 39 - 25).[3]—

Section 1.—At the end of the second sentence add the words "compression specimens." Connect the second and third sentences with the word "but," omitting the words "These methods" at the beginning of the present third sentence.

Section 2.—In the fourth sentence change the word "sifted" to "sieved."

Section 5.—In Paragraph (*b*) omit the words "(natural sand only)."

In Paragraph (*c*) change the word "or" before the word "dust" to "and."

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[1] 1924 Book of A.S.T.M. Standards.

[2] A.S.T.M. Standards Adopted in 1926.

[3] A.S.T.M. Standards Adopted in 1925.

In Paragraph (*e*) add a reference to the Standard Specifications and Tests for Portland Cement (Serial Designation: C 9) of the American Society for Testing Materials.

Section 6 (*b*).—Change the word "or" before the word "dust" to "and." Change the reference in this section to Section 5 (*d*) to the Standard Method of Test for Quantity of Clay and Silt in Gravel for Highway Construction (Serial Designation: D 72) of the American Society for Testing Materials.

Section 8.—Change the fourth sentence to read as follows by the addition of the italicized words:

> "The quantities of materials may be expressed as (a) 1 volume of cement to — volumes of total aggregate mixed as used, or (b) 1 volume of cement, — volumes of fine aggregate, and — volumes of coarse aggregate, *or (c) 1 part by weight of cement, — parts by weight of fine aggregate, and — parts by weight of coarse aggregate.*"

Section 10.—In the second sentence of Paragraph (*a*) change the words "galvanized steel" to "metal."

Change Paragraph (*e*) to read as follows by the addition of the italicized words and the omission of those in brackets:

> "The [whole] *mass* shall be mixed thoroughly until the [entire mass] *resulting concrete* is homogeneous in appearance."

Section 11 (*b*).—Change from its present form: namely,

> "Flow test made by placing a metal form in the shape of a frustum of a cone 6¾ in. in top diameter, 10 in. in bottom diameter, 5 in. deep, on the table of the flow apparatus. The fresh concrete shall be placed in the mold in two layers. Each layer shall be puddled and finished as described in Section 13. Immediately after molding, the form shall be removed by a steady upward pull; the specimen raised ½ in. and dropped 15 times in about 6 seconds by means of a suitable cam and crank. The spread of the fresh concrete due to this treatment as compared with the original bottom diameter of the cone, expressed as a percentage, is the 'flow.'"

to read as follows:

> "Flow test made by placing a metal mold in the shape of a frustrum of a cone 6¾ in. in top diameter, 10 in. in bottom diameter, 5 in. deep, on the table of the flow apparatus. The fresh concrete shall be placed in the mold in two layers. Each layer shall be puddled as described in Section 13. Immediately after molding, the surplus concrete shall be struck off with a trowel and the mold shall be removed by a steady upward pull; the table raised ½ in. and dropped 15 times in about 10 seconds by means of a suitable cam and crank. The spread of the fresh concrete due to this treatment expressed as a percentage of the original bottom diameter of the cone is the 'flow.'"

Section 12.—Change the word "forms" to "molds."

Section 13.—Change the second sentence from its present form: namely,

> "Each layer shall be puddled with 25 strokes with a ⅝ in. round steel bar of a length 9 in. greater than the length of the mold, pointed at the lower end."

to read as follows:

> "Each layer shall be puddled with 25 strokes with a ⅝-in. rod 24 in. long, bullet-pointed at the lower end."

Section 14.—Change from its present form: namely,

> "Two to four hours after molding, the test pieces shall be capped with a thin layer of stiff neat cement paste in order that the cylinders may present a smooth end for loading. The cap shall be formed by means of a machined metal plate or a piece of plate glass of suitable size, at least ¼ in. thick, worked down on the fresh cement paste until it rests on the top of the cylinder form. The cement for capping shall be mixed to a stiff paste before beginning to mix the concrete; in this way the tendency of the cap to shrink will be largely eliminated. The adhesion of the concrete to the metal base plate and the glass can be largely eliminated by oiling the cover plate and by inserting a sheet of paraffined tissue paper."

to read as follows:

> "Two to four hours after molding, the test specimens shall be capped with a thin layer of stiff neat cement paste in order that the cylinder may present a smooth end for testing. The cap shall be formed by means of a piece of plate glass ¼ in. thick or a machined metal plate ½ in. thick and of a diameter 2 or 3 in. larger than that of the mold. The plate is worked on the fresh cement paste until it rests on top of the mold. The cement for capping should be mixed to a stiff paste 2 to 4 hours before it is to be used in order to avoid the tendency of the cap to shrink. Adhesion of the concrete to the top and bottom plates may be avoided by oiling the plates or by inserting a sheet of paraffined paper."

Section 19.—In the second sentence change the word "placed" to "used." In the fifth sentence omit the word "approximately," and change the word "as" to "or slightly larger than." In the last sentence insert the words "or lower" after the word "upper."

Section 23.—Change to read as follows by the addition of the italicized words and the omission of the word in brackets:

> "Density and yield of concrete when required shall be calculated from the unit volumes of the constituent materials and the volume of the *fresh or set* concrete *as desired.* Density is here understood to be the ratio of solids in the concrete to the total volume of the mass. Yield is the volume of concrete resulting from [one] *the* volume of aggregate mixed as used."

Tentative Method of Securing Specimens of Hardened Concrete from the Structure (*C 42 - 25* T).[1]—It is recommended that this tentative method be advanced to standard, with the following changes:

Section 2.—Omit the word "content" after the word "mortar."

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 25, Part I, p. 631 (1925); also 1926 Book of A.S.T.M. Tentative Standards, p. 310.

Section 4 (c).—Change the word "point" in the first sentence to "place."

Section 6.—Change the side-heading to read "Ends of Test Specimens." Insert the words "by capping" after the word "surfaces" and "thin layer of" between the words "a" and "mortar."

Section 7.—Add a new side-heading to read "Strength Correction Factor." In the last sentence of the first paragraph change the words "should be made as follows" to "shall be made as indicated in the following table." Add a sentence to read as follows: "Values not given in the table shall be determined by interpolation."

Change the last paragraph of this section to a new Section 8, adding a side heading to read: "Test Precautions."

Tentative Specifications for Concrete Aggregates (C 33 – 26 T).[1]—

Section 2.—Change the limits appearing under the first paragraph of this section from the present form: namely,

"Passing ⅜-in. sieve		100	per cent
Passing No. 4 sieve		85	"
Passing No. 50 sieve	not more than	25	"
	not less than	5	"
Weight removed by decantation test,	not more than	3	" "

to read as follows:

"Passing ⅜-in. sieve	100	per cent
Passing No. 4 (4760 micron) sieve, not less than	85	"
Passing No. 50 (297 micron) sieve	5 to 25	per cent"

Add a new Section 3, to read as follows, renumbering the subsequent sections accordingly:

> "3. (*a*) Weight removed by the decantation test shall be not more than 3 per cent."

Make the fourth paragraph under Section 2, Section 3 (*b*).

Section 4 (b).—Change from its present form: namely,

> "Upon failure to meet this requirement, the proportion of cement in the concrete mixture shall be increased or the proportions of cement, fine aggregate, coarse aggregate and water changed in such a way as to produce the strength specified in Section 6."

to read as follows:

> "(*b*) Sands failing to meet this requirement may still be considered acceptable provided the strength requirements specified in Section 7 (*a*) or (*b*) are fulfilled."

Section 6.—Omit the last sentence, reading as follows:

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 26, Part I, p. 741 (1926); also 1926 Book of A.S.T.M. Tentative Standards, p. 256.

"Upon failure to meet this requirement, the proportion of cement in the concrete mix shall be increased or the proportions of cement, fine aggregate, coarse aggregate and water shall be changed in such a way as to produce the specified strength."

Add a new Paragraph (*b*) to read as follows:

"Sands failing to meet this requirement may be considered acceptable provided it is possible to readjust the proportions of cement, fine aggregate, coarse aggregate and water so as to produce concrete of the strength specified."

Section 9.—In Paragraphs (*a*) and (*b*) add the micron equivalents for the designations of sieves.

Add a new Section 11 to read as follows:

"(*a*) *Methods of Sampling and Testing.*—The method of sampling concrete aggregates shall be in accordance with the Standard Methods of Sampling Stone, Slag, Gravel, Sand and Stone Block for Use as Highway Materials Including Some Material Survey Methods (Serial Designation: D 75) of the American Society for Testing Materials.

"(*b*) The sieve analysis shall be made in accordance with the Standard Method of Test for Sieve Analysis of Aggregate for Concrete (Serial Designation: C 41) of the American Society for Testing Materials."

Respectfully submitted on behalf of the sub-committee,

A. T. GOLDBECK,
Chairman.

APPENDIX I

A STUDY OF THE DATA OF "SERIES 201" AND WISCONSIN TESTS SHOWING THE RELATION OF THE COMPRESSIVE STRENGTH OF CONCRETE TO THE WATER-CEMENT RATIO, SPACE-CEMENT RATIO AND GRADING OF THE AGGREGATE

By R. A. Nelson

In order to test the validity of the several theories for the design of concrete mixes, Mr. B. F. Smith and the author under the direction of Prof. M. O. Withey of the University of Wisconsin undertook a study of the published data on the compressive strength of concrete obtained in "Series 201"[1] by the collaborating laboratories of the Philadelphia Department of Public Works, the University of Texas, the University of Toronto, and the Hydro-Electric Power Commission of Ontario. These data are supplemented by the results herein reported of a series of tests performed at the University of Wisconsin in accordance with the outline of Series 201 by R. Shaw and M. C. Steffen as their thesis for the Bachelor of Science degree in Civil Engineering. (See Table I.) The results of our study were incorporated in a thesis for the same degree and are abstracted herein.

Scope of Study

Abrams' strength - water-cement ratio relationship and the strength - space-cement ratio relationship, a modification of Talbot's strength - cement-space ratio relationship, were studied with a great deal of care and in considerable detail. A cursory examination was also made of the relationship of strength of concrete to fineness modulus, surface area, and surface modulus of mixed aggregate, and relative consistency of mix.

Methods of Calculation

There were four main steps in this study: (1) assuming the basic data published in the report of Committee C-9 and in the Wisconsin thesis of Shaw and Steffen to be correct, the derived results were checked; (2) certain necessary additional results were calculated; (3) the results of the strength tests were plotted on semi-log, log-log, and rectangular co-ordinate graph paper to determine the equations of the mean curves representing relationships; and (4) from a comparison of the curves certain conclusions were drawn.

The following equations indicate the method of using the test data to calculate results: Let W_a, W_c, W_k, and 62.4 equal the weight in pounds per cubic foot of the mixed aggregate, cement, concrete, and water, respectively; S_a, S_c, and S_k, the specific gravity of the mixed aggregate, cement, and con-

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[1] An Outline of Tests "Series 201" by Sub-Committees II and VI of Committee C-9 may be found in *Proceedings*, Am. Soc. Testing Mats., Vol. XX, Part I, p. 294 (1920). Reports of collaborating laboratories are summarized by D. A. Abrams in Appendix II, Report of Committee C-9, ***Proceedings***, Am. Soc. Testing Mats., Vol. 22, Part I, p. 329 (1922).

TABLE I.—WISCONSIN TESTS: COMPRESSION TESTS OF CONCRETE.

(Supplementary to "Series 201," Tests by Shaw and Steffen.)

Mix by Volume	Relative Consistency	Water Ratio	Concrete Tests					
			Unit Weight, lb. per cu. ft.	Density	Voids, v	Cement, c	$\frac{v+c}{c}$	Compressive Strength, lb. per sq. in.
FINENESS MODULUS, 2.73.								
1:5.....	0.80	1.00	125	0.667	0.333	0.083	5.00	576
	0.90	1.20	129	0.667	0.323	0.084	4.84	651
	1.00	1.35	132	0.689	0.311	0.086	4.62	711
	1.10	1.48	132	0.678	0.322	0.084	4.84	639
	1.25	1.68	134	0.677	0.323	0.084	4.86	570
	1.50	2.04	135	0.663	0.337	0.082	5.10	663
FINENESS MODULUS, 4.50.								
1:7.....	0.90	1.24	142	0.770	0.230	0.064	4.60	857
	1.00	1.38	143	0.769	0.230	0.064	4.60	688
	1.10	1.51	143	0.765	0.234	0.064	4.60	792
	1.25	1.72	142	0.753	0.246	0.063	4.91	655
1:5.....	0.80	0.76	135	0.743	0.257	0.084	4.06	1028
	0.90	0.86	141	0.767	0.235	0.087	3.70	1524
	1.00	0.95	144	0.778	0.225	0.088	3.56	1986
	1.10	1.04	143	0.770	0.233	0.087	3.68	1426
	1.25	1.19	144	0.762	0.240	0.086	3.79	1390
	1.50	1.43	145	0.752	0.250	0.085	3.95	1038
1:3.5...	0.90	0.66	144	0.775	0.223	0.119	2.88	2553
	1.00	0.74	146	0.779	0.220	0.120	2.83	2974
	1.10	0.81	145	0.771	0.228	0.119	2.92	3022
	1.25	0.92	145	0.762	0.236	0.118	3.00	2680
FINENESS MODULUS, 5.50.								
1:7.....	0.90	0.99	145	0.802	0.198	0.065	4.05	1410
	1.00	1.10	147	0.806	0.194	0.066	3.94	1574
	1.10	1.20	150	0.815	0.185	0.066	3.80	1421
	1.25	1.36	149	0.803	0.197	0.066	4.00	953
1:5.....	0.80	0.65	143	0.791	0.208	0.087	3.40	1483
	0.90	0.74	149	0.816	0.181	0.090	3.01	3020
	1.00	0.81	150	0.815	0.183	0.090	3.04	2910
	1.10	0.90	150	0.810	0.189	0.089	3.12	2584
	1.25	1.02	149	0.802	0.197	0.088	3.24	1860
	1.50	1.22	150	0.790	0.208	0.087	3.40	1133
1:3.5...	0.90	0.56	146	0.792	0.206	0.119	2.73	2906
	1.00	0.62	151	0.817	0.188	0.122	2.54	3700
	1.10	0.68	150	0.805	0.194	0.121	2.60	3452
	1.25	0.77	150	0.796	0.203	0.120	2.69	3312
FINENESS MODULUS, 5.75.								
1:7.....	0.90	0.91	147	0.815	0.185	0.066	3.81	748
	1.00	1.01	148	0.810	0.190	0.066	3.88	1541
	1.10	1.11	150	0.813	0.187	0.066	3.84	1220
	1.25	1.26	150	0.810	0.190	0.066	3.88	1204
1:5.....	0.80	0.66	147	0.810	0.190	0.089	3.14	2352
	0.90	0.74	150	0.823	0.177	0.090	2.97	2692
	1.00	0.82	150	0.820	0.180	0.090	3.00	2706
	1.10	0.90	151	0.817	0.183	0.090	3.03	2588
	1.25	1.02	150	0.801	0.199	0.088	3.26	1678
	1.50	1.23	149	0.790	0.210	0.087	3.42	1147
1:3.5...	0.90	0.56	149	0.810	0.190	0.121	2.56	3714
	1.00	0.62	151	0.815	0.185	0.122	2.52	3740
	1.10	0.68	150	0.805	0.195	0.120	2.63	3396
	1.25	0.78	150	0.800	0.200	0.120	2.67	2622

TABLE I.—WISCONSIN TESTS: COMPRESSION TESTS OF CONCRETE—(*Continued*).

Mix by Volume	Relative Consistency	Water Ratio	Concrete Tests					
			Unit Weight, lb. per cu. ft.	Density	Voids, v	Cement, c	$\frac{v+c}{c}$	Compressive Strength, lb. per sq. in.
FINENESS MODULUS, 6.00.								
1:7.....	0.90	0.83	146	0.810	0.190	0.068	3.80	1726
	1.00	0.92	147	0.812	0.188	0.068	3.76	1824
	1.10	1.01	147	0.805	0.195	0.067	3.91	1411
	1.25	1.15	149	0.811	0.189	0.068	3.78	1210
1:5.....	0.80	0.60	144	0.795	0.205	0.090	3.28	2088
	0.90	0.68	150	0.826	0.174	0.093	2.87	3216
	1.00	0.75	151	0.826	0.174	0.094	2.85	3166
	1.10	0.83	152	0.825	0.175	0.093	2.88	2404
	1.25	0.95	151	0.813	0.187	0.092	3.03	1856
	1.50	1.15	151	0.800	0.200	0.091	3.20	1130
1:3.5...	0.90	0.56	152	0.825	0.175	0.127	2.38	4178
	1.00	0.62	151	0.818	0.182	0.126	2.44	3990
	1.10	0.68	152	0.814	0.186	0.125	2.49	2902
	1.25	0.78	150	0.798	0.202	0.123	2.64	2940
FINENESS MODULUS, 6.25.								
1:7.....	0.90	0.80	144	0.796	0.204	0.070	2.92	1769
	1.00	0.84	146	0.805	0.195	0.070	3.79	1680
	1.10	0.98	146	0.796	0.204	0.070	3.92	1290
	1.25	1.11	150	0.816	0.184	0.071	3.60	1188
1:5.....	0.80	0.55	144	0.793	0.207	0.093	3.23	2422
	0.90	0.63	149	0.818	0.182	0.096	2.90	3396
	1.00	0.69	150	0.824	0.176	0.097	2.82	2854
	1.10	0.77	150	0.815	0.185	0.096	2.93	2358
	1.25	0.87	151	0.813	0.187	0.096	2.95	2056
	1.50	1.05	151	0.801	0.199	0.094	3.12	1392
1:3.5...	0.90	0.54	151	0.818	0.182	0.131	2.39	4194
	1.00	0.60	152	0.816	0.184	0.131	2.40	3822
	1.10	0.66	151	0.808	0.192	0.129	2.49	3290
	1.25	0.75	151	0.799	0.201	0.128	2.57	2760
FINENESS MODULUS, 6.50.								
1:5.....	0.80	0.53	138	0.763	0.237	0.092	3.58	1798
	0.90	0.59	146	0.800	0.200	0.096	3.09	2664
	1.00	0.66	146	0.797	0.203	0.096	3.12	2656
	1.10	0.72	146	0.794	0.206	0.095	3.17	2290
	1.25	0.82	148	0.798	0.202	0.096	3.10	1953
	1.50	0.97	150	0.795	0.205	0.096	3.14	1312

crete, respectively; D_a, D_c, and D_k, the total solids per unit volume of, or density of, the mixed aggregate, cement, and concrete, respectively; y, the yield (volume of concrete from one volume of mixed aggregate); n, the number of volumes of mixed aggregate to one volume of cement (the mix); x, the water-cement ratio (ratio of volume of water to volume of cement); and c, the absolute volume of cement and v the absolute volume of voids per cubic foot of concrete. Then

$$y = \frac{W_a + \frac{W_c}{n} + \frac{62.4x}{n}}{W_k}; \quad D_a = \frac{W_a}{62.4\ S_a}; \quad D_c = \frac{W_c}{62.4\ S_c}$$

$D_k = \dfrac{D_a + \dfrac{D_c}{n}}{y}$; $v = 1 - D_k$; $c = \dfrac{D_c}{yn}$. Calculations of the space-cement ratio $\dfrac{(v + c)}{c}$ were made for the Wisconsin, Texas Standard, Texas Rodded and Ontario-Power-Commission tests, which were the only series in which sufficient data were available. The space-cement ratio results are given in Tables II to IV and supplement the previously reported results of Series 201.

TABLE II.—TEXAS STANDARD TESTS.[1]

Mix by Volume	Relative Consistency	Voids, v	Cement, c	$\frac{v+c}{c}$	Mix by Volume	Relative Consistency	Voids, v	Cement, c	$\frac{v+c}{c}$
FINENESS MODULUS, 3.48.					FINENESS MODULUS, 5.50.				
1:7......	0.90	0.269	0.068	4.96	1:7......	0.90	0.169	0.070	3.42
	1.00	0.281	0.067	5.22		1.00	0.171	0.069	3.46
	1.10	0.282	0.067	5.24		1.10	0.187	0.068	3.66
	1.25	0.306	0.064	5.75		1.25	0.191	0.068	3.81
1:5......	0.90	0.260	0.092	3.81	1:5......	0.90	0.157	0.095	2.65
	1.00	0.279	0.090	4.10		1.00	0.168	0.094	2.78
	1.10	0.291	0.089	4.27		1.10	0.175	0.093	2.87
	1.25	0.299	0.088	4.39		1.25	0.182	0.092	2.97
1:3.5....	0.90	0.242	0.128	2.89	1:3.5....	0.90	0.152	0.131	2.16
	1.00	0.249	0.126	2.98		1.00	0.162	0.130	2.25
	1.10	0.283	0.124	3.28		1.10	0.172	0.128	2.34
	1.25	0.268	0.123	3.18		1.25	0.181	0.126	2.46
FINENESS MODULUS, 6.00.					FINENESS MODULUS, 6.50.				
1:7......	0.90	0.148	0.070	3.12	1:7......	0.90	0.131	0.075	2.78
	1.00	0.147	0.070	3.10		1.00	0.131	0.075	2.78
	1.10	0.161	0.069	3.32		1.10	0.138	0.075	2.86
	1.25	0.169	0.069	3.43		1.25	0.157	0.073	3.15
1:5......	0.90	0.134	0.097	2.38	1:5......	0.90	0.136	0.101	2.35
	1.00	0.141	0.097	2.45		1.00	0.148	0.100	2.48
	1.10	0.149	0.096	2.55		1.10	0.162	0.098	2.55
	1.25	0.156	0.095	2.64		1.25	0.173	0.096	2.80
1:3.5....	0.90	0.144	0.131	2.09	1:3.5....	0.90	0.143	0.136	2.05
	1.00	0.155	0.130	2.19		1.00	0.153	0.135	2.13
	1.10	0.158	0.128	2.23		1.10	0.165	0.133	2.24
	1.25	0.168	0.127	2.32		1.25	0.180	0.131	2.43

PROCEDURE IN MAKING GRAPHS

In making the graphs the results were omitted for tests in which the fineness modulus of the mixed aggregate exceeded 6.00 or in which the relative consistency was less than 1.00 since concrete outside these limitations is too harsh and too dry to be effectively placed under average field conditions. Each plotted point represents the average strength of five cylinders.

The graphs made on semi-log and log-log graph paper are shown for the Wisconsin tests only. The purpose of including these graphs is merely to show the method followed generally in determining whether the exponential or hyperbolic function best fitted the plotted points. Considering all of the tests, it was found that the exponential function was slightly more representative of the mean of the plotted points than the hyperbolic function. Hence, only the exponential function is shown on the graphs for the tests other than the Wisconsin tests.

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[1] Supplementary to Table IX in Report of Committee C-9, Appendix II, *Proceedings*, Am. Soc. Testing Mats., Vol. 22, Part I, pp. 339 and 340 (1922).

RELATIONSHIP BETWEEN WATER-CEMENT AND SPACE-CEMENT RATIOS

Since the relationship of strength to water-cement ratio is a straight line on semi-log graph paper, and the relationship of strength to space-cement ratio is also a straight line on semi-log graph paper, it follows that there is a linear relationship for any given strength between the water-cement ratio and the space-cement ratio. This relationship was determined for each series of tests by placing the two equations for strength equal to each other and solving for the water-cement ratio, x, in terms of the space-cement ratio, z. This equation was then used in placing a second abscissa scale on the strength graphs which would represent values of the space-cement ratio that were applicable to the plotted points and mean exponential curve already drawn on those graphs.

TABLE III.—TEXAS RODDED TESTS.[1]

Mix by Volume	Relative Consistency	Voids, v	Cement, c	$\frac{v+c}{c}$	Mix by Volume	Relative Consistency	Voids, v	Cement, c	$\frac{v+c}{c}$
FINENESS MODULUS, 3.48.					FINENESS MODULUS, 5.50.				
1:7......	0.90	0.252	0.070	4.62	1:7......	0.90	0.144	0.072	3.01
	1.00	0.253	0.070	4.65		1.00	0.143	0.072	2.98
	1.10	0.254	0.070	4.66		1.10	0.143	0.072	3.03
	1.25	0.244	0.068	4.60		1.25	0.147	0.072	3.05
1:5......	0.90	0.230	0.097	3.36	1:5......	0.90	0.139	0.098	2.41
	1.00	0.235	0.097	3.42		1.00	0.139	0.098	2.41
	1.10	0.228	0.097	3.34		1.10	0.150	0.096	2.56
	1.25	0.228	0.097	3.34		1.25	0.150	0.098	2.53
1:3.5....	0.90	0.214	0.134	2.60	1:3.5....	0.90	0.144	0.132	2.09
	1.00	0.204	0.134	2.52		1.00	0.148	0.131	2.13
	1.10	0.214	0.134	2.60		1.10	0.151	0.131	2.15
	1.25	0.214	0.132	2.58		1.25	0.154	0.131	2.17
FINENESS MODULUS, 6.00.					FINENESS MODULUS, 6.50.				
1:7......	0.90	0.120	0.072	2.66	1:7......	0.90	0.126	0.076	2.67
	1.00	0.143	0.072	2.98		1.00	0.121	0.076	2.59
	1.10	0.124	0.072	2.73		1.10	0.123	0.076	2.63
	1.25	0.127	0.072	2.77		1.25	0.123	0.076	2.61
1:5......	0.90	0.122	0.099	2.25	1:5......	0.90	0.117	0.103	2.13
	1.00	0.118	0.099	2.19		1.00	0.121	0.103	2.18
	1.10	0.126	0.099	2.27		1.10	0.129	0.103	2.26
	1.25	0.126	0.098	2.29		1.25	0.129	0.103	2.26
1:3.5....	0.90	0.134	0.134	2.00	1:3.5....	0.90	0.140	0.138	2.02
	1.00	0.134	0.132	2.02		1.00	0.136	0.138	1.98
	1.10	0.148	0.132	2.12		1.10	0.125	0.139	1.90
	1.25	0.138	0.132	2.04		1.25	0.140	0.136	2.03

[1] Supplementary to Table IX in Report of Committee C-9, Appendix II, *Proceedings*, Am. Soc. Testing Mats., Vol. 22, Part I, pp. 339 and 340 (1922).

TYPES OF GRAPHS

In order to ascertain the probable variations in strength from the mean curve for strengths between the ordinary working limits of 1500 to 3500 lb. per sq. in., curves representing 85 and 115 per cent of the mean curve were drawn. The number and per cent of results above the mean, above 85 per cent of the mean and above the lowest plotted point were determined and recorded on the figure.

Results of the strength tests of individual cylinders were available for the Wisconsin and Texas experiments. These results were also plotted on strength graphs to determine the amount of variation in strength of individual cylinders from the mean curve previously determined.

Graphs were made showing the relationship of the strength of concrete to the fineness modulus, surface area and surface modulus of the mixed aggregate, the same curve representing the relationship when read to the proper abscissa scale. The results were separated according to relative consistency. Graphs were also made showing the relationship of the strength of concrete to the relative consistency of the mix, the results being separated according to fineness modulus.

As a final step in making the graphs, the mean curves showing the relationship of strength to water-cement ratio for each set of tests were drawn on **Fig. 1** and the average curve selected.

Strength - Water-Cement Ratio Relationship

Derived Equations.—The equations of the mean curves for the individual tests are as follows:

Wisconsin................ $S = \frac{17,800}{10^x}$ (adopted as the mean of the upper four equations)

Texas Standard........... $S = \frac{12,400}{7.94^x}$

Ontario.................. $S = \frac{18,000}{9.02^x}$

Toronto.................. $S = \frac{17,000}{9.7^x}$

Texas Rodded............ $S = \frac{9,300}{3.66^x}$

Philadelphia............. $S = \frac{12,000}{11.9^x}$

where S = compressive strength in pounds per square inch; and
x = water-cement ratio.

The average of the mean curves for the first four tests is taken as the Wisconsin mean curve, the equation of which is:

$$S = \frac{17,800}{10^x}$$

This equation is applicable with the following restrictions:

1. Portland cement must pass A.S.T.M. Standard Specifications and Tests for Cement (C-9);[1]
2. Aggregate should conform to A.S.T.M. Tentative Specifications for Concrete Aggregates (C 33 - 26 T)[2], and its fineness modulus should not exceed 6.00;

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[1] A.S.T.M. Standards Adopted in 1926.

[2] *Proceedings*, Am. Soc. Testing Mats., Vol. 26, Part I, p. 741 (1926); also 1926 Book of A.S.T.M. Tentative Standards, p. 256.

3. The relative consistency of the mix should lie between 1.00 and 1.50.

If these restrictions are exceeded, a new equation must be determined experimentally, using the proposed materials and methods.

The Texas-Rodded Tests are not considered in selecting the average curve since they represent different conditions. This series shows that rodding of concrete in placing greatly increases its strength. Between the ordinary working limits of 1500 to 3500 lb. per sq. in., the strength is increased about 25 per cent over the strength obtained for standard conditions of placement.

In this selection the Philadelphia tests were also ignored because of the low strength which may have been due to the character of the fine aggregate used.

Variation of Results.—Considering the results representing the average strength of five cylinders, it was found that, between the limits of 1500 to 3500

TABLE IV.—ONTARIO POWER COMMISSION TESTS.[1]

Mix by Volume	Relative Consistency	Voids, v	Cement, c	$\frac{v+c}{c}$	Mix by Volume	Relative Consistency	Voids, v	Cement, c	$\frac{v+c}{c}$
FINENESS MODULUS, 3.82					FINENESS MODULUS, 4.50.				
1:7......	0.80	0.313	0.064	5.93	1:7......	0.80	0.277	0.066	5.22
	0.90	0.308	0.064	5.78		0.90	0.264	0.065	5.06
	1.00	0.292	0.066	5.45		1.00	0.242	0.067	4.63
	1.10	0.280	0.067	5.20		1.10	0.234	0.067	4.47
	1.25	0.284	0.066	5.30		1.25	0.264	0.065	5.06
	1.50	0.309	0.064	5.65		1.50	0.256	0.064	5.03
1:5......	0.80	0.306	0.087	4.52	1:5......	0.80	0.257	0.088	3.92
	0.90	0.300	0.088	4.41		0.90	0.254	0.088	3.88
	1.00	0.274	0.091	4.00		1.00	0.238	0.091	3.62
	1.10	0.254	0.093	3.73		1.10	0.247	0.089	3.78
	1.25	0.287	0.089	4.22		1.25	0.264	0.088	4.00
	1.50	0.300	0.088	4.41		1.50	0.275	0.086	4.20
1:3.5....	0.80	0.297	0.120	3.47	1:3.5....	0.80	0.265	0.119	3.23
	0.90	0.280	0.123	3.28		0.90	0.232	0.124	2.87
	1.00	0.265	0.125	3.12		1.00	0.236	0.124	2.90
	1.10	0.265	0.125	3.12		1.10	0.254	0.121	3.10
	1.25	0.297	0.120	3.47		1.25	0.267	0.119	3.24
	1.50	0.300	0.119	3.52		1.50	0.270	0.118	3.29
FINENESS MODULUS, 5.50.					FINENESS MODULUS, 5.75.				
1:7......	0.80	0.213	0.067	4.16	1:7......	0.80	0.215	0.067	4.19
	0.90	0.213	0.067	4.16		0.90	0.200	0.069	3.92
	1.00	0.213	0.067	4.16		1.00	0.200	0.069	3.92
	1.10	0.220	0.067	4.30		1.10	0.212	0.068	4.13
	1.25	0.235	0.066	4.58		1.25	0.231	0.066	4.49
	1.50	0.249	0.064	4.86		1.50	0.238	0.066	4.62
1:5......	0.80	0.216	0.091	3.38	1:5......	0.80	0.212	0.092	3.30
	0.90	0.200	0.092	3.17		0.90	0.203	0.092	3.20
	1.00	0.200	0.092	3.17		1.00	0.189	0.094	3.01
	1.10	0.216	0.091	3.37		1.10	0.211	0.092	3.29
	1.25	0.238	0.088	3.71		1.25	0.226	0.090	3.51
	1.50	0.238	0.088	3.71		1.50	0.233	0.089	3.62
1:3.5....	0.80	0.228	0.122	2.85	1:3.5....	0.80	0.237	0.121	2.96
	0.90	0.214	0.124	2.73		0.90	0.209	0.125	2.67
	1.00	0.206	0.123	2.65		1.00	0.209	0.125	2.67
	1.10	0.220	0.123	2.79		1.10	0.223	0.123	2.81
	1.25	0.234	0.121	2.93		1.25	0.237	0.121	2.96
	1.50	0.247	0.119	3.08		1.50	0.237	0.121	2.96

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[1] Supplementary to Table XX in Report of Committee C-9, Appendix II, *Proceedings*, Am. Soc. Testing Mats., Vol. 22, Part I, pp. 348–351 (1922).

TABLE IV.—ONTARIO POWER COMMISSION TESTS—(*Continued*).

Mix by Volume	Relative Consistency	Voids, v	Cement, c	$\frac{v+c}{c}$	Mix by Volume	Relative Consistency	Voids, v	Cement, c	$\frac{v+c}{c}$
FINENESS MODULUS, 6.00.					FINENESS MODULUS, 6.25.				
1:7......	0.80	0.210	0.068	4.09	1:7......	0.80	0.209	0.069	4.00
	0.90	0.208	0.069	4.03		0.90	0.200	0.070	3.86
	1.00	0.194	0.069	3.79		1.00	0.190	0.071	3.69
	1.10	0.207	0.069	4.02		1.10	0.190	0.071	3.69
	1.25	0.225	0.067	4.38		1.25	0.218	0.069	4.18
	1.50	0.240	0.066	4.66		1.50	0.225	0.068	4.30
1:5......	0.80	0.207	0.092	3.25	1:5......	0.80	0.212	0.093	3.28
	0.90	0.191	0.094	3.03		0.90	0.189	0.096	2.97
	1.00	0.183	0.095	2.93		1.00	0.189	0.096	2.97
	1.10	0.205	0.092	3.23		1.10	0.205	0.094	3.18
	1.25	0.228	0.090	3.53		1.25	0.212	0.093	3.28
	1.50	0.235	0.089	3.64		1.50	0.220	0.092	3.39
1:3.5....	0.80	0.240	0.121	2.98	1:3.5....	0.80	0.246	0.122	3.02
	0.90	0.205	0.126	2.63		0.90	0.197	0.130	2.52
	1.00	0.198	0.127	2.56		1.00	0.188	0.131	2.44
	1.10	0.219	0.124	2.77		1.10	0.218	0.126	2.77
	1.25	0.233	0.122	2.91		1.25	0.225	0.125	2.80
	1.50	0.233	0.122	2.91		1.50	0.232	0.124	2.87
FINENESS MODULUS, 6.50.									
1:7......	0.80	0.182	0.074	3.47					
	0.90	0.208	0.072	3.90					
	1.00	0.190	0.073	3.60					
	1.10	0.207	0.072	3.89					
	1.25	0.231	0.069	4.32					
	1.50	0.231	0.069	4.32					
1:5......	0.80	0.235	0.093	3.53					
	0.90	0.195	0.098	3.00					
	1.00	0.203	0.097	3.09					
	1.10	0.203	0.097	3.09					
	1.25	0.220	0.095	3.31					
	1.50	0.227	0.094	3.42					
1:3.5....	0.80	0.253	0.124	3.04					
	0.90	0.195	0.133	2.46					
	1.00	0.202	0.132	2.53					
	1.10	0.268	0.129	3.08					
	1.25	0.224	0.129	2.74					
	1.50	0.238	0.126	2.89					

lb. per sq. in. and for all of the six tests, 81 out of 85 or about 95 per cent of the plotted points lie above 85 per cent of their respective mean curves.

For the tests of individual cylinders (Wisconsin, Texas Standard, and Texas Rodded) within the same limits, it was found that 184 out of 205 or about 90 per cent of the plotted points lie above 85 per cent of their respective mean curves, and that 204 out of 205 or about 99.5 per cent of the plotted points lie above 75 per cent of their respective mean curves.

Average Equation.—The equation of the average of the mean curves is:

$$S = \frac{17{,}800}{10^x}$$

The equation developed by Abrams is:

$$S = \frac{14{,}000}{7^x}$$

For values of strength between the ordinary working limits of 1500 to 3500 lb. per sq. in., the two equations give results within 10 per cent of each other.

STRENGTH - SPACE-CEMENT RATIO RELATIONSHIP

The equations for the mean curves representing the strength - space-cement ratio relationship for the various tests are as follows:

Wisconsin.. $S = \dfrac{31{,}000}{2.25^z}$

Texas Standard.................................... $S = \dfrac{29{,}500}{2.63^z}$

Texas Rodded...................................... $S = \dfrac{37{,}000}{2.94^z}$

Ontario... $S = \dfrac{18{,}300}{2.07^z}$

where S = strength in pounds per square inch, and

z = space-cement ratio, $\dfrac{v + c}{c}$.

The relationship was not determined for the Toronto or the Philadelphia tests.

This relationship is represented by the same curves as the strength - water-cement ratio relationship, provided proper abscissa scales are used. The relationships between the abscissa scales for the various tests are as follows:

Wisconsin.................................. $x = 0.355z - 0.241$
Texas Standard............................ $x = 0.467z - 0.418$
Texas Rodded.............................. $x = 0.833z - 1.065$
Ontario..................................... $x = 0.331z - 0.007$

where x = water-cement ratio, $\dfrac{w}{c}$, and

z = space-cement ratio, $\dfrac{v + c}{c}$.

RELATIONSHIP OF STRENGTH OF CONCRETE TO FINENESS MODULUS, SURFACE AREA, AND SURFACE MODULUS OF AGGREGATE

For increasing fineness modulus and decreasing surface area and surface modulus, the curves representing the relationship of strength of concrete to fineness modulus, surface area, and surface modulus of the mixed aggregate gradually slope upward to a maximum strength and then drop off rapidly. This point of maximum strength, in general, occurs at a fineness modulus of 6.00, a surface area of 750 sq. in., and a surface modulus of 5.5. The same curve can be made to represent each of the three relationships providing proper abscissa scales are used.

RELATIONSHIP OF STRENGTH OF CONCRETE TO RELATIVE CONSISTENCY OF MIX

The mean curves representing the relationship of the strength of concrete to the relative consistency of the mix show that a maximum strength is obtained for a relative consistency of 0.90 to 1.00. The strength falls off rapidly for relative consistencies greater or less than these values.

CONCLUSIONS

1. The study of the relationship of strength to water-cement ratio shows that the relationship is best represented by an equation of the form $S = \frac{A}{B^x}$, where S = compressive strength in pounds per square inch, x = water-cement ratio, and A and B are constants depending upon the character of the ingredients and the conditions of fabrication, placing and curing.

2. The average equation, $S = \frac{17,800}{10^x}$, or, in round numbers, $S = \frac{18,000}{10^x}$, is a very easy equation to use from a mathematical point of view. It gives results from 5 to 10 per cent less than Abrams' equation, $S = \frac{14,000}{7^x}$, for strengths between the ordinary working limits of 1500 to 3500 lb. per sq. in.

3. Since the strength - space-cement ratio relationship can be represented by the same curve as the strength - water-cement ratio relationship providing proper abscissa scales are used, with the aid of this curve the strength of concrete can be determined from either the space-cement ratio or water-cement ratio. Hence, it is inferred that these ratios are very similar measures of strength.

4. Since the relationship of strength of concrete to fineness modulus, surface area, and surface modulus of the mixed aggregate can be represented by the same curve providing proper abscissa scales are used, and since fineness modulus, surface area, and surface modulus are each calculated from the sieve analysis, it is concluded that these indices are very similar. The fineness modulus is a very easily determined criterion of the grading of the aggregate.

5. The marked decline in the strength of concrete for any given mix and for relative consistencies greater than 1.00 or less than 0.90 shows how important is the effect of the proportion of mixing water on the strength of the resulting concrete.

[For a discussion on the design of concrete mixtures, see page 386.—ED.]

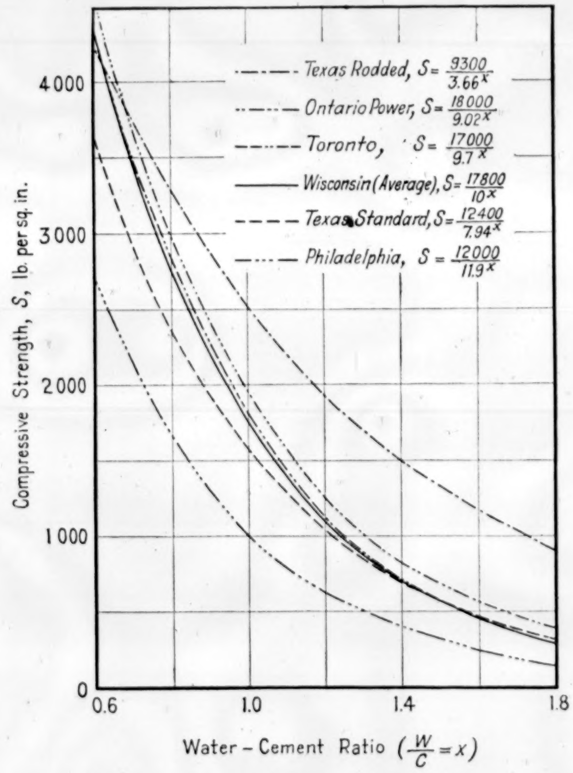

FIG. 1.—Relation of Compressive Strength to Water-Cement Ratio: Summary Curves.

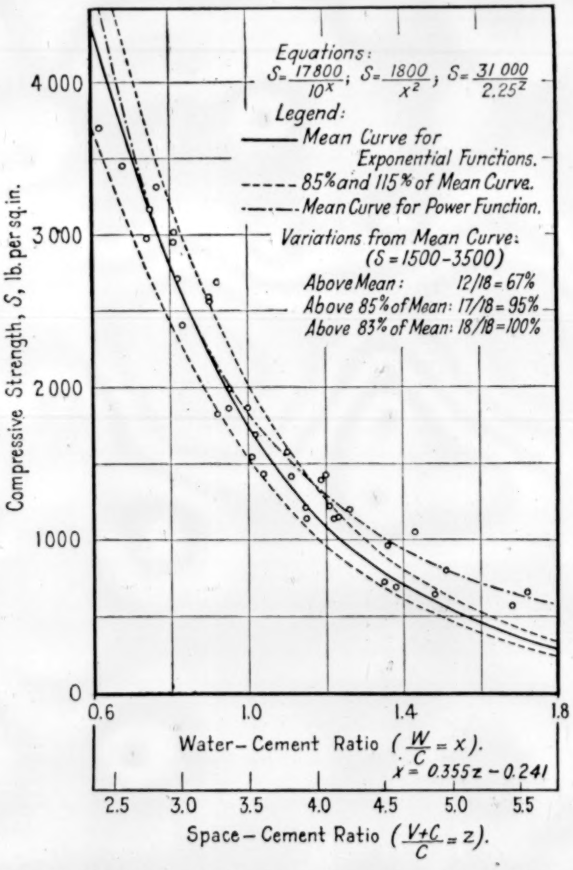

FIG. 2.—Relation of Compressive Strength to Water-Cement Ratio and Space-Cement Ratio (Wisconsin Test).

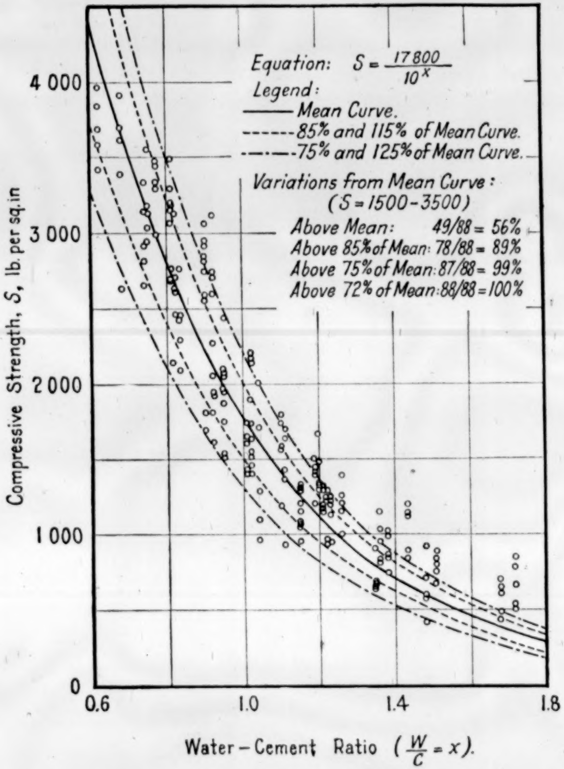

FIG. 3.—Relation of Compressive Strength to Water-Cement Ratio (Wisconsin Test, Individual Results).

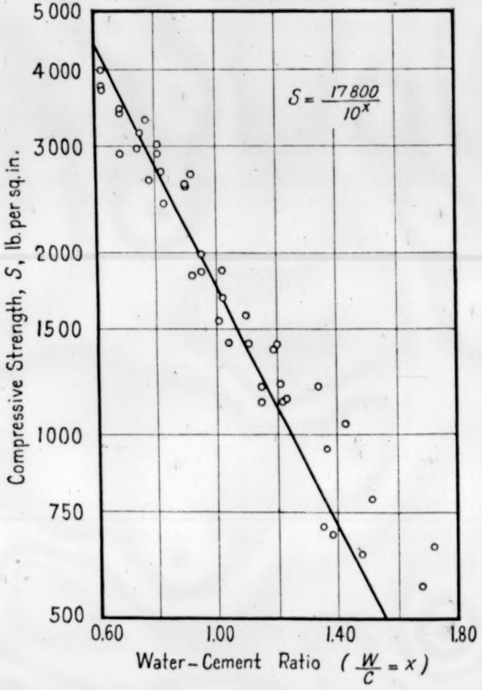

FIG. 4.—Relation of Compressive Strength to Water-Cement Ratio (Wisconsin Test).

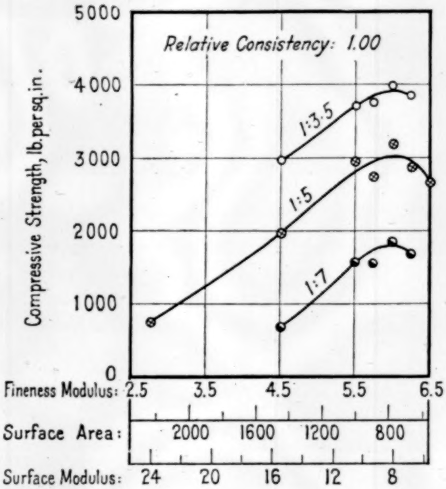

FIG. 5.—Relation of Compressive Strength to Fineness Modulus, Surface Area and Surface Modulus (Wisconsin Test).

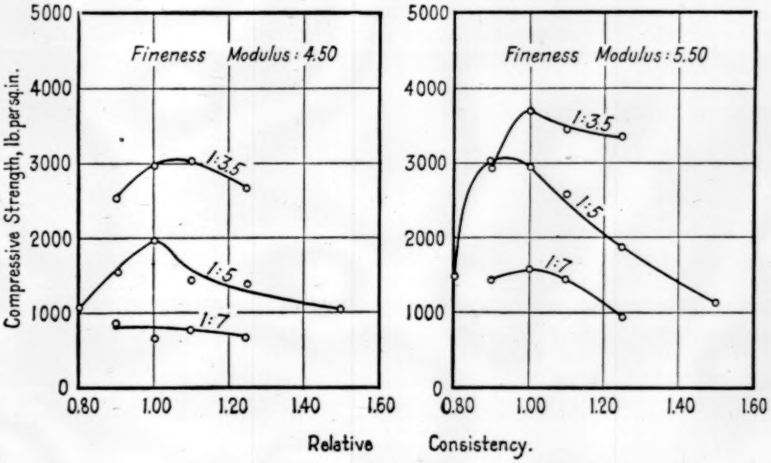

FIG. 6.—Relation of Compressive Strength to Relative Consistency (Wisconsin Test).

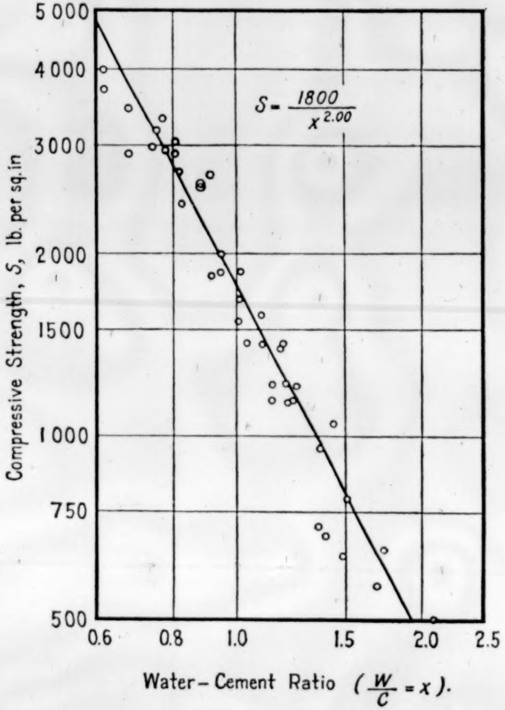

FIG. 7.—Relation of Compressive Strength to Water-Cement Ratio (Wisconsin Test).

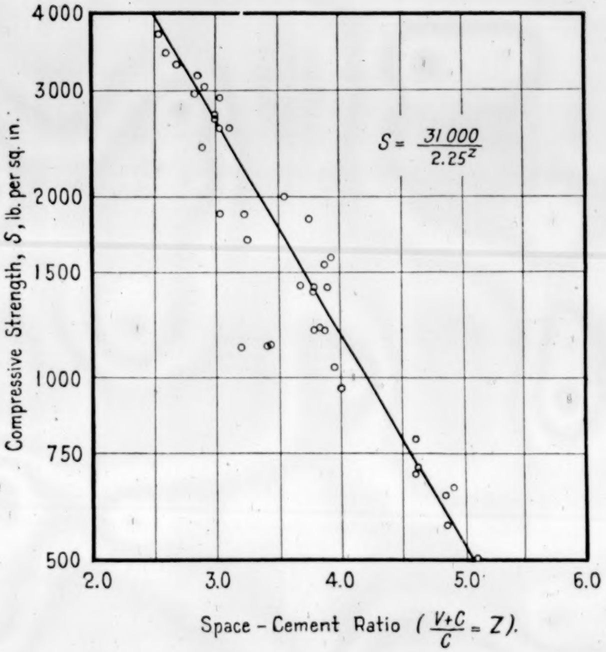

FIG. 8.—Relation of Compressive Strength to Space-Cement Ratio (Wisconsin Test).

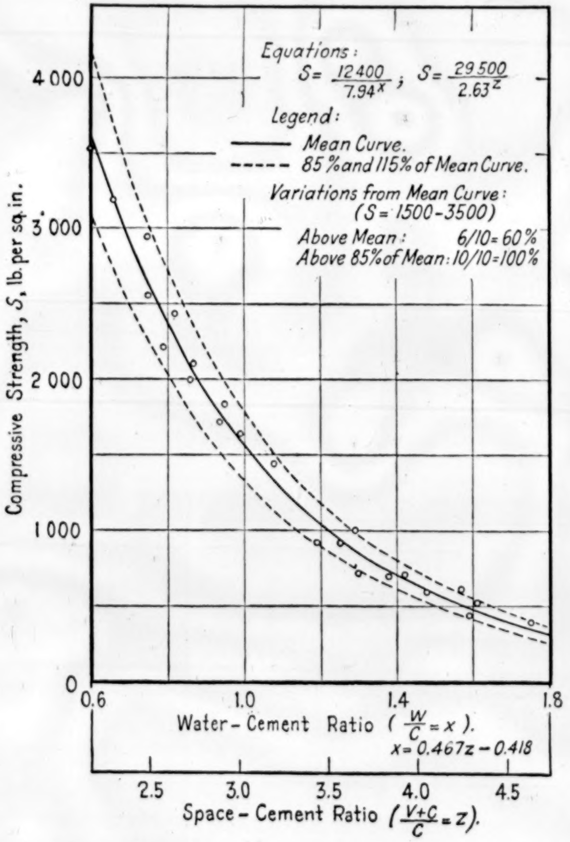

FIG. 9.—Relation of Compressive Strength to Water-Cement Ratio and Space-Cement Ratio (Texas Standard Test).

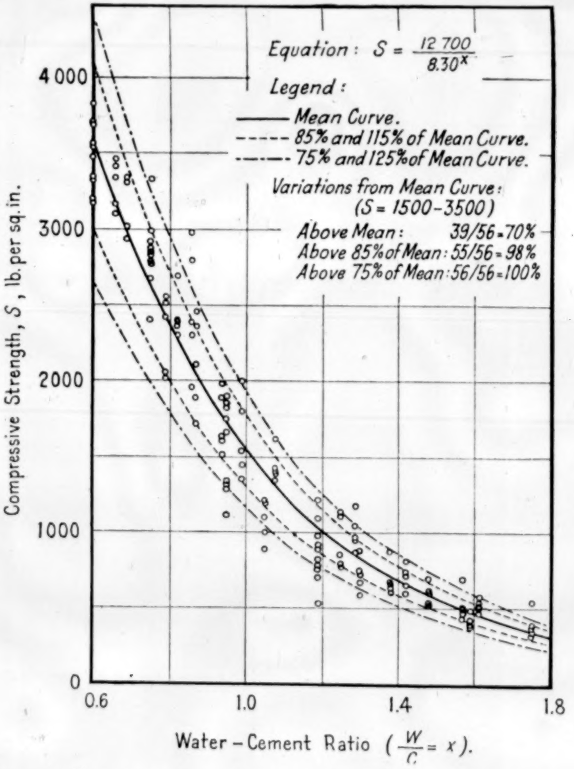

FIG. 10.—Relation of Compressive Strength to Water-Cement Ratio (Texas Standard Test, Individual Results).

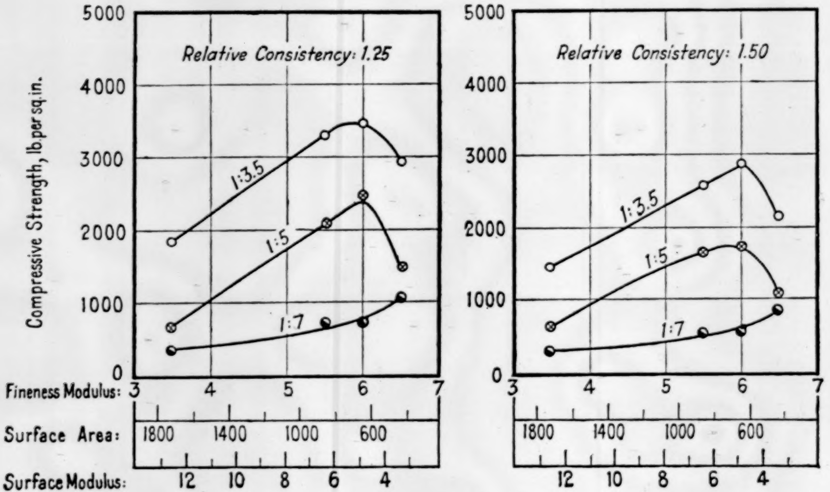

FIG. 11.—Relation of Compressive Strength to Fineness Modulus, Surface Area and Surface Modulus (Texas Standard Test).

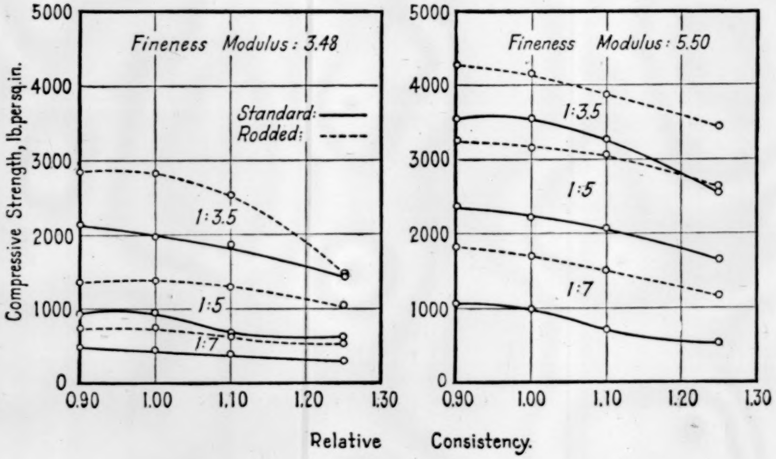

FIG. 12.—Relation of Compressive Strength to Relative Consistency (Texas Test).

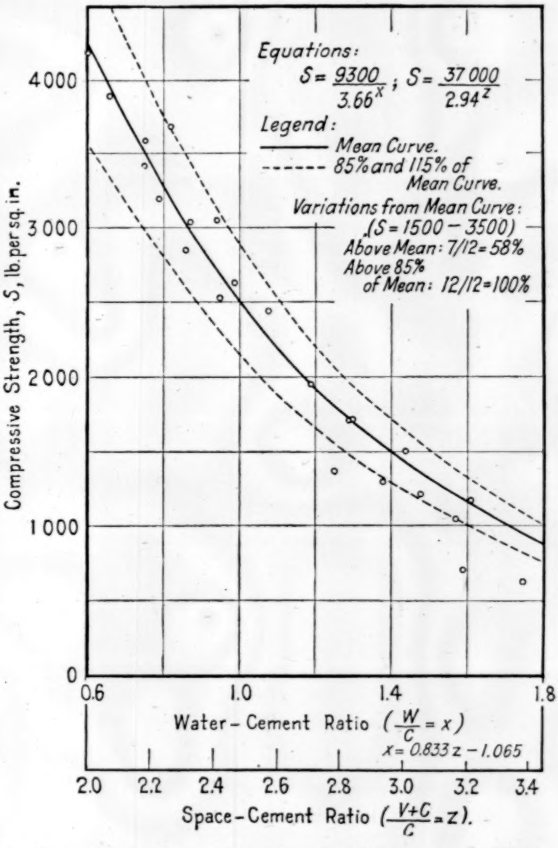

FIG. 13.—Relation of Compressive Strength to Water-Cement Ratio and Space-Cement Ratio (Texas Rodded Test).

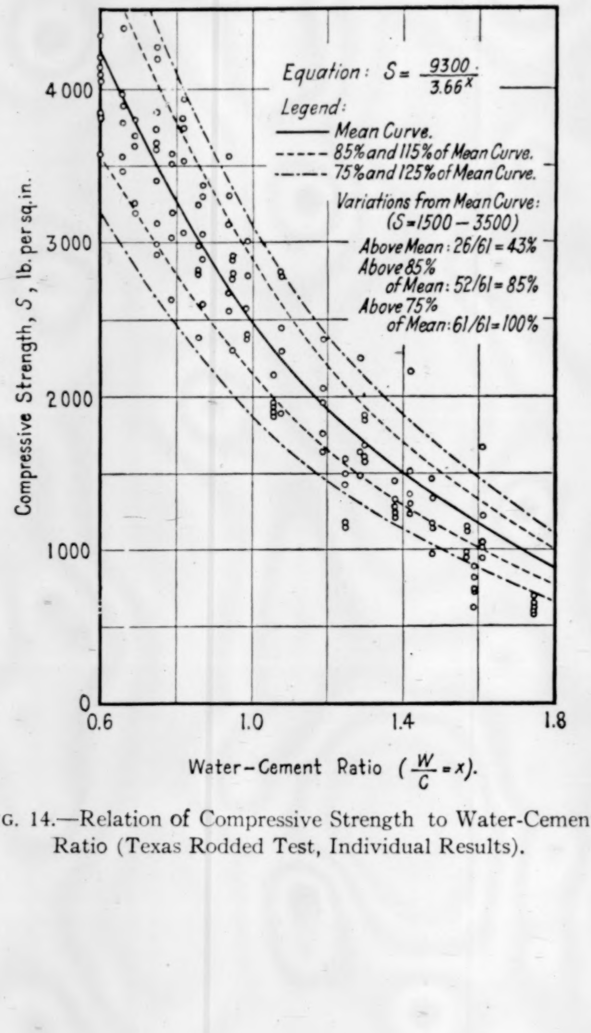

FIG. 14.—Relation of Compressive Strength to Water-Cement Ratio (Texas Rodded Test, Individual Results).

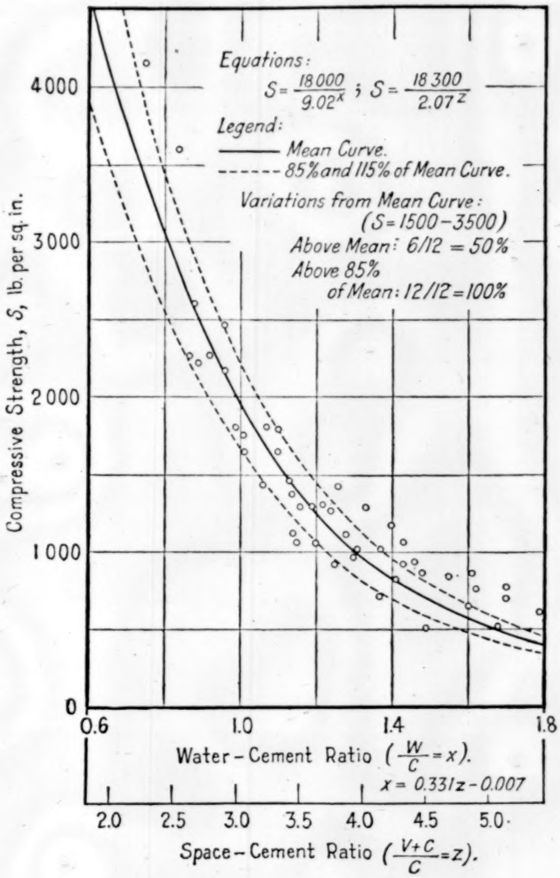

FIG. 15.—Relation of Compressive Strength to Water-Cement Ratio and Space-Cement Ratio (Ontario Test).

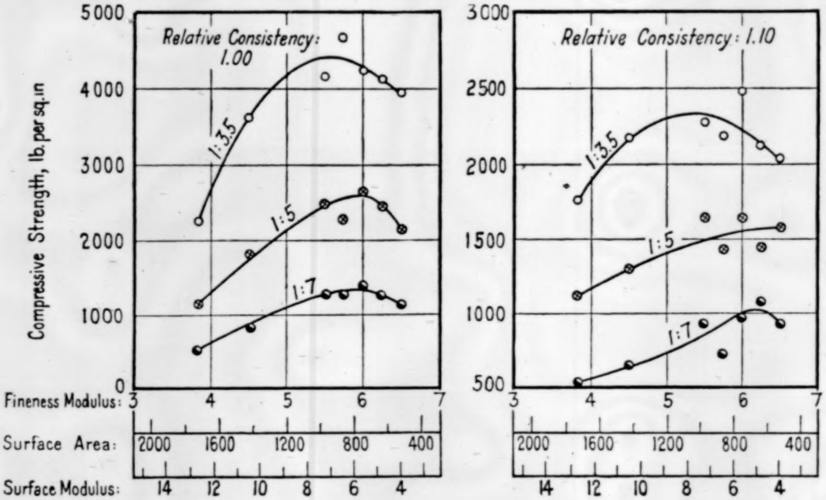

FIG. 16.—Relation of Compressive Strength to Fineness Modulus, Surface Area and Surface Modulus (Ontario Test).

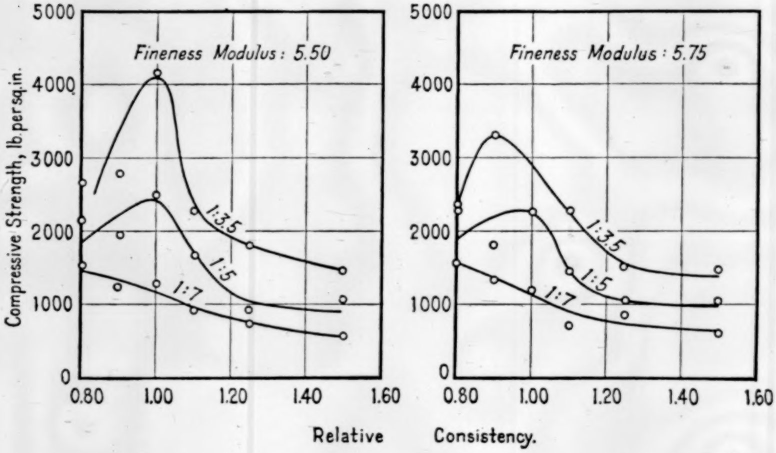

FIG. 17.—Relation of Compressive Strength to Relative Consistency (Ontario Test).

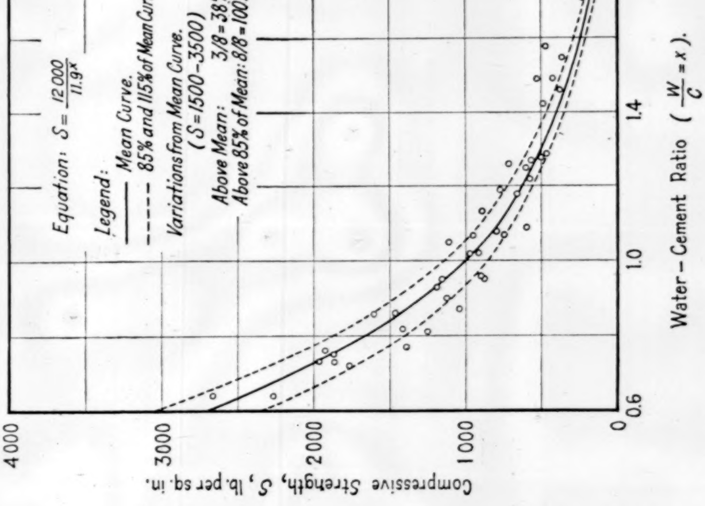

FIG. 18.—Relation of Compressive Strength to Water-Cement Ratio (Philadelphia Test).

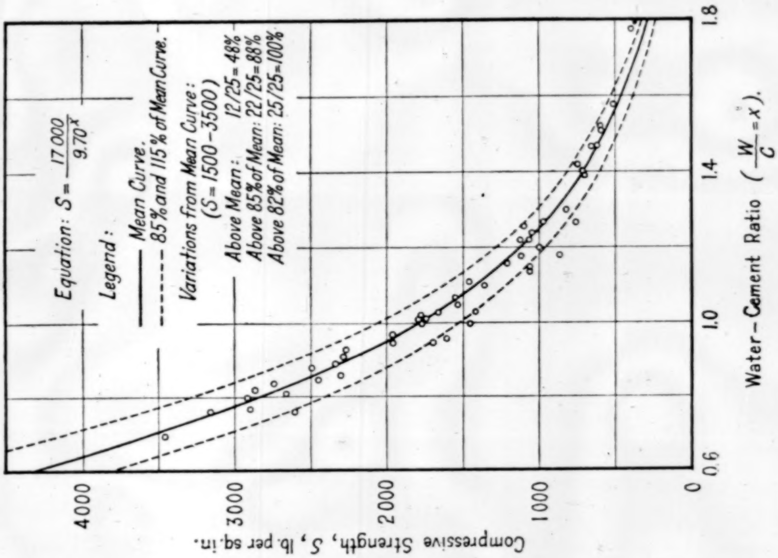

FIG. 19.—Relation of Compressive Strength to Water-Cement Ratio (Toronto Test).

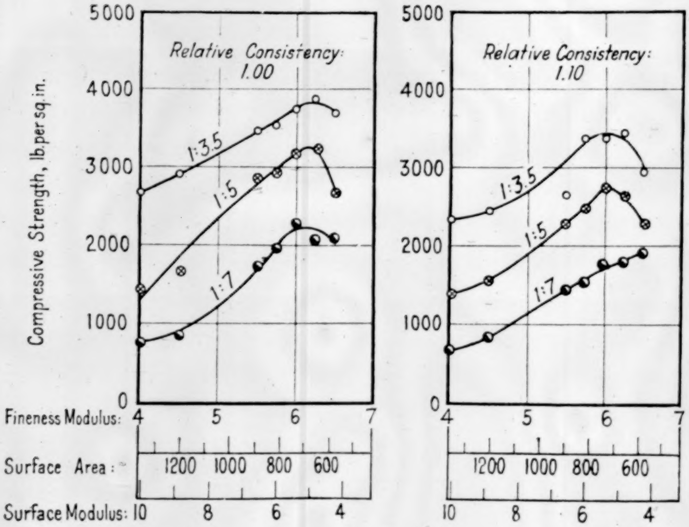

FIG. 20.—Relation of Compressive Strength to Fineness Modulus, Surface Area and Surface Modulus (Toronto Test).

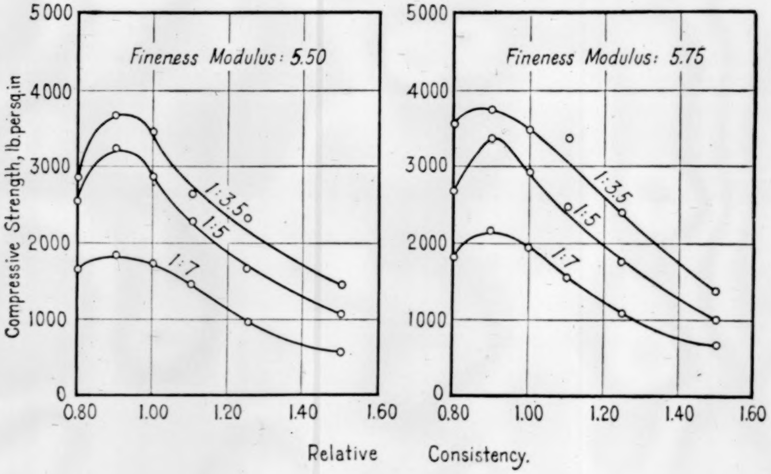

FIG. 21.—Relation of Compressive Strength to Relative Consistency (Toronto Test).

APPENDIX II

RECOMMENDED REVISION OF CHAPTER V OF THE 1924 REPORT OF THE JOINT COMMITTEE

ON

STANDARD SPECIFICATIONS FOR CONCRETE AND REINFORCED CONCRETE

CHAPTER V. PROPORTIONING AND MIXING CONCRETE

A. *Proportioning*

Proportioning of the mix may be based primarily either upon a specified "maximum water content," with approximate proportions of aggregate, or upon definite proportions of aggregate without specifying maximum water content.

27. *Unit of Measure.*—The unit of measure for cement and aggregates shall be the cubic foot or pound. Ninety-four pounds of portland cement (1 sack or $\frac{1}{4}$ bbl.) shall be as considered 1 cu. ft. The unit of measure for water shall be the U. S. gallon (231 cu. in.).

28. *Measurement of Cement, Aggregates and Water.*—The measurement of the component materials may be either by weight or by volume, except that the bulk cement must be always measured by weight. In either case, the method shall be such as to give the equivalent of the specified quantities in each batch, and to insure uniformity of successive batches. In volume measurement of aggregate, unless inundated, the measure shall be filled loosely and struck off, the volume being adjusted to give the correct equivalent of the dry and rodded proportions as specified.[1]

When "Maximum Water Content" is specified in Table IV, the free moisture carried by the aggregate shall be considered as part of the mixing water, and methods used shall be such that this water can be determined readily and the quantity of water to be added to the batch adjusted accordingly, so that the maximum water content shall not exceed that specified in Table IV.

29. *Proportions and Consistency.*—Concrete shall be mixed in the proportions specified in Table IV for the various parts of the structure.

When the ***maximum water content*** is specified in Table IV, the aggregate proportions may be changed to give the desired workability, within the limits of Table V. When the maximum water content is not specified in Table IV, the proportions specified therein for fine and coarse aggregates shall be strictly adhered to and no change shall be made therein without the consent of the Engineer.

Whichever plan of proportioning is followed, whether maximum water content or definite proportions of aggregates, the slumps shall fall within the limits specified, and the mixtures shall at all times be such that the concrete can be worked into the angles and corners of the forms and around the rein-

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[1] See note (*a*) to Table IV.

TABLE IV.—PROPORTIONS FOR CONCRETE.[a]

Part of Structure	Maximum Water Content, U. S. gal. per 94-lb. sack of Portland Cement	Cement, sacks or lb.	Dry Aggregates, lb. or rodded cu. ft.		Limiting Slump, in.		Compressive Strength of Concrete at 28 Days Assumed as Basis for Design, lb. per sq. in.
			Fine	Coarse	Minimum	Maximum	
Caissons, heavy foundations, massive walls	....	....	....	....	[b]	[b]	[c]
Pavements, floor slabs on ground, etc	....	....	....	....	....	....	[d]
Ordinary building walls, reinforced	....	....	....	....	....	....	....
Slabs, beams, girders, etc	....	....	....	....	....	....	....
Thin walls, columns	....	....	....	....	....	....	....

[a] These proportions have been selected on the basis of average aggregates conforming to the requirements in Sections 6 to 16[1] to give a workability for the specified maximum water content which in the opinion of the Engineer is suitable for the various parts of the structure. The Engineer must insert the maximum water content when such is specified and proportions for the various classes of concrete. These should preferably be determined by tests in advance, using the available aggregate, cement and water and the proportions of aggregate and the maximum water content necessary to produce concrete of the required qualities. Where this is impracticable the following maximum water content may be used:

Compressive Strength of Concrete at 28 Days Assumed as Basis for Design, lb. per sq. in.	Maximum Water Content, U. S. gal. Water per 94-lb. Sack of Portland Cement
4000	5
3500 (600, modulus of rupture)	$5\frac{1}{2}$
3000 (550, " " ")	6
2500 (500, " " ")	$6\frac{1}{2}$
2000	$7\frac{1}{4}$
1500	8

In the absence of tests the approximate proportions of fine and coarse aggregate may be selected from Appendix 16[1] which is based on volumes of dry aggregate compacted by rodding in the measure, as specified in the Standard Method of Test for Unit Weight of Aggregate for Concrete (Serial Designation: C 29 - 21) of the American Society for Testing Materials. Corrections should be made in the quantities to take account of the bulking of the fine aggregate due to moisture. The bulking of fine aggregate (swelling) due to contained moisture, and the method of placing in the measure, unless compensated for, may result in a reduction of as much as 30 per cent in the actual quantity of fine aggregate, as compared with that obtained by the standard method of dry measurement. The coarse aggregate may bulk from 5 to 10 per cent above its dry rodded volume, due to the method of field measurement.

[b] The engineer must insert the minimum and maximum slumps which will be permitted for the different portions of the structure. He may, however, reserve the right to designate, at any time during the progress of the work, narrower limits of slump than those named in the contract, provided such narrower limits fall within the limits first named. The following slumps are recommended as limits for various uses in order that consistencies which are unnecessarily wet or too stiff for proper placement may be avoided:

Class of Concrete or Part of Structure	Limiting Values of Slump, in.	
	Minimum	Maximum
Caissons, heavy foundations, massive walls	1	4
Pavements, floor slabs on ground, etc	1	4
Ordinary building walls, reinforced	3	6
Slabs, beams, girders, etc	4	7
Thin walls, columns	4	7

[c] The Engineer must insert concrete strengths to be used as basis for design.

[d] For pavements and similar structures in which flexural resistance is important, the "modulus of rupture" should be used as the basis for design.

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[1] 1924 Report of the Joint Committee on Standard Specifications for Concrete and Reinforced Concrete, *Proceedings*, Am. Soc. Testing Mats, Vol. 24, Part I, p. 303 (1924).

forcement, without harshness or segregation or the accumulation of water or laitance on the surface or the production of honeycomb in the mass.

Changes in proportions made necessary by the use of aggregates of grading or type other than those specified in Sections 6 to 16[1] shall be made at the contractor's expense and no claim for extra compensation arising from such changes shall be honored.

Where changes in proportions are ordered by the Engineer or changes in quantities resulting from the use of other changes in the maximum water content, they shall be compensated for under the clauses in the contract covering extras and credits.

TABLE V.—LIMITING PROPORTIONS OF FINE AND COARSE AGGREGATE.

(For use with "maximum water content" method.)

Maximum Size of Coarse Aggregate, in.	Ratio of Coarse to Fine Aggregate on Basis of Dry Rodded Volumes	
	Minimum	Maximum
$\frac{1}{2}$	0.4	0.7
$\frac{3}{4}$	0.7	1.5
1 and over	1.0	2.0

30. *Tests.*—To assure a concrete of the required strength, the Engineer may require the making of strength tests during the progress of the work. Such tests shall be made in accordance with the standard methods of the American Society for Testing Materials.

It shall be the duty of the contractor to keep within the maximum water content (when such is specified) and consistency as measured by the slump. When definite proportions are specified by volume, the Engineer shall determine the bulking of the aggregates above their dry rodded volume due to moisture and method of field measurement and shall determine the volume of measures to be used in proportioning on the job.

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[1] 1924 Report of the Joint Committee on Standard Specifications for Concrete and Reinforced Concrete, *Proceedings*, Am. Soc. Testing Mats., Vol. 24, Part I, p. 303 (1924).

DISCUSSION

Mr. Abrams. MR. D. A. ABRAMS.[1]—As I see concrete, it consists of two essential factors: (1) the cementing value of the cement, and (2) the dispersion of the particles of cement with reference to each other and with reference to the aggregates. One of the important functions of water in concrete is to produce a plastic mass. If we put more water in we simply spread each particle so much farther from its neighbor and from the aggregate. In our original studies at Lewis Institute, we took the quantity of water as a proper measure of dispersion. It could be expressed as a space ratio, since we are dealing with exactly the same thing. In other words, the quantity of water is a direct measure of this space ratio. The authors of this paper might have taken one more step and pointed that out in their discussion.

The curves shown by Mr. Withey for the different laboratories and the different series of tests would not be expected to be coincident, due to the use of cements of different values and to variations in manipulations, temperature, etc., and naturally different constants are obtained if you attempted to fit equations to them. One of the principal reasons for variation is the properties of the cement. The Germans have gone a step farther than we have in the use of this type of equation, by actually plotting a family of curves from which one may choose the curve which corresponds to the type of cement used. One might have a curve for a low-strength natural cement, and a set of curves for Portland cement of different types, and still another curve for the higher strength cement, etc. Difficulties would certainly be encountered in any attempt to reconcile tests made by different laboratories under different conditions, since we should not expect to secure the same constant.

Mr. Withey. MR. M. O. WITHEY.[2]—Since Mr. Nelson plainly states in his paper that the relationship of compressive strength to water-cement ratio is very similar to the relationship of strength to space-cement ratio, I fail to appreciate Mr. Abrams' inference that such an important conclusion had been omitted.

I think Mr. Abrams' statement that strength - water-cement-ratio curves obtained with different cements or by different laboratories are likely to differ more or less due to inherent variables is noteworthy. This fact should be thoroughly appreciated by users of such diagrams.

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[1] Director of Research, International Cement Corporation, New York City.

[2] Professor of Mechanics, University of Wisconsin, Madison, Wis.

REPORT OF COMMITTEE C-10
ON
HOLLOW MASONRY BUILDING UNITS

The committee held three meetings during the past year. By the election of three and the resignation of one member, the committee now has 24 members, of which 14 are non-producers and 10 are producers. All sections of the country, except the Northwest, are now represented both by producers and non-producers. An effort is being made to obtain representation from this section.

Much of the work of the committee has been based on results obtained from fire and compression tests of walls and strength tests of floor slabs made by the U. S. Bureau of Standards in cooperation with the Hollow Building Tile Association, to both of which organizations acknowledgment is due. In addition, a copy of a report by Prof. Kreuger, a Swedish investigator, entitled "Investigations on Climatic Action on the Exteriors of Building Fronts" has been made available to the committee.

Several minor changes have been made in the existing standards and tentative standards. The details of the recommendations of the committee on the various specifications are given under the headings to which they are applicable.

STANDARD SPECIFICATIONS AND TESTS FOR HOLLOW BURNED-CLAY LOAD-BEARING WALL TILE (C 34 – 26)[1]

Section 6. Fire Resistance.—The table giving the fire resistance periods has been enlarged to include 16-in. walls having 6 cells through the wall. These changes are based on values obtained from recent fire tests of heavy walls. The proposed revised table is as follows:

THICKNESS OF WALL, IN.	NUMBER OF UNITS IN WALL THICKNESS	NUMBER OF CELLS IN WALL	RESISTANCE PERIOD, HOURS
8	1	2	1½
8	1	3	2
12	1	3	3
12	2	3	4
12	2	4	5
16	2 or 3	4	6
16	*2 or 3*	*6*	*8*

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[1] A.S.T.M. Standards Adopted in 1926.

Section 21. Capping.—Change the first sentence of Paragraph (*a*) to read as follows by the omission of the words in brackets:

> "Bearing surfaces of the test samples and portions adjoining them which are liable to absorb water from the plastic capping shall be coated with [one coat of] shellac and allowed to dry."

Change the last sentence of Paragraph (*c*) from its present form: namely,

> "Any other method of capping which produces equally satisfactory results may be used."

to read as follows:

> "If the tile so capped fail to pass specification requirements on the score of strength, they shall be retested with portland-cement-gypsum caps aged not less than three days."

Section 23. Position of Tile.—Change from its present form: namely,

> "All tile shall be tested in the position in which they are designed to be used."

to read as follows:

> "All tile shall be tested in a position such that the load is applied in the same direction as in service."

These revisions are recommended to the Society for adoption as standard immediately. The committee accordingly asks for the necessary nine-tenths vote.

TENTATIVE SPECIFICATIONS AND TESTS FOR HOLLOW BURNED-CLAY FIREPROOFING, PARTITION AND FURRING TILE (C 56 – 26 T)[1]

Section 2 (a) Classification.—Changes in form are recommended to avoid ambiguity in classification and in the strength requirements to bring them in accord with those in the Standard Specifications C 34. The changes in the strength requirements are in most cases small. They are suggested by Sub-Committee I on Strength and Load Tests after a comprehensive study of test data giving a comparison between the compressive strength of tile based on net and gross area.

With the new strength values, it is expected that tiles having the same physical properties will be placed in the same class by all of the specifications promulgated by this committee. It is recommended that Section 2 (*a*) be changed from its present form: namely,

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 26, Part I, p. 751 (1926); also 1926 Book of A.S.T.M. Tentative Standards, p. 271.

"(*a*) According to the results of physical tests, tile shall be classified as Hard, Medium, and Soft on the basis of the following requirements:[a]

Class	Absorption, per cent		Compressive Strength Based on Net Area, lb. per sq. in.			
			End Construction		Side Construction	
	Mean of 5 Tests	Individual Maximum	Mean of 5 Tests	Individual Minimum	Mean of 5 Tests	Individual Minimum
Hard	12 or less	15	3000 or more	2500	2000 or more	1500
Medium	12 to 20	25	3000 to 2000	1500	2000 to 1250	1000
Soft	20 to 28	35	2000 to 1000	750	1250 to 750	500

[a] As different types of clay are used in the manufacture of tile, color cannot be taken as indicative of classification."

to read as follows:

"(*a*) According to the results of physical tests, tile shall be classified as Hard, Medium, and Soft on the basis of the following strength and absorption requirements, both of which must be met for a given class:

Class	Absorption, per cent		Compressive Strength Based on Net Area, lb. per sq. in.			
			End Construction		Side Construction	
	Mean of 5 Tests	Individual Maximum	Mean of 5 Tests	Individual Minimum	Mean of 5 Tests	Individual Minimum
Hard	12 or less	15	4600 or more	3000	2400 or more	1700
Medium	16 or less	19	3200 or more	2250	1600 or more	1100
Soft	25 or less	28	2000 or more	1400	1200 or more	850

[b] As different types of clay are used in the manufacture of tile, color cannot be taken as indicative of classification."

Section 3 (*a*) *Weights.*—In the table of weights it is recommended that a 4-cell 6 by 12 by 12-in. unit weighing 25 lb. be added. It is also recommended that the weight of the 4-cell 10 by 12 by 12-in. unit be changed from 36 to 35 lb. These revisions are intended to make the values conform with present manufacturing practice.

Section 20. Capping.—Change the first sentence of Paragraph (*a*) to read as follows by the omission of the words in brackets:

> "Bearing surfaces of the test samples and portions adjoining them which are liable to absorb water from the plastic capping shall be coated with [one coat of] shellac and allowed to dry."

Change the last sentence of Paragraph (*c*) from its present form: namely, "Any other method of capping which produces equally satisfactory results may be used."

to read as follows:

"If the tile so capped fail to pass specification requirements on the score of strength, they shall be retested with portland-cement-gypsum caps aged not less than three days."

Section 22. Position of Tile.—Change from its present form: namely,

"All tile shall be tested in the position in which they are designed to be used."

to read as follows:

"All tile shall be tested in a position such that the load is applied in the same direction as in service."

The committee recommends that the specifications be revised as indicated and that they be continued as tentative in their proposed revised form.

TENTATIVE SPECIFICATIONS AND TESTS FOR HOLLOW BURNED-CLAY FLOOR TILE (C 57 - 26 T)[1]

Section 2 (a) Classification.—Changes in form are recommended to avoid ambiguity in classification and in the strength requirements to bring them in accord with those in the Standard Specifications C 34. The changes in the strength requirements are in most cases small.

It is accordingly recommended that Section 2 (*a*) be changed from its present form: namely,

"(*a*) According to the results of physical tests, tile shall be classified as Hard, Medium, and Soft on the basis of the following requirements:[a]

Class	Absorption, per cent		Compressive Strength Based on Net Area, lb. per sq. in.			
			End Construction		Side Construction	
	Mean of 5 Tests	Individual Maximum	Mean of 5 Tests	Individual Minimum	Mean of 5 Tests	Individual Minimum
Hard	12 or less	15	4000 or more	3200	2500 or more	2000
Medium	12 to 16	19	4000 to 3000	2400	2500 to 1800	1400
Soft	16 to 25	28	3000 to 2200	1700	1800 to 1300	1000

[a] As different types of clay are used in the manufacture of tile, color cannot be taken as indicative of classification."

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 26, Part I, p. 756 (1926); also 1926 Book of A.S.T.M. Tentative Standards, p. 276.

to read as follows:

"(*a*) According to the results of physical tests, tile shall be classified as Hard, Medium, and Soft on the basis of the following strength and absorption requirements, both of which must be met for a given class:[b]

Class	Absorption, per cent		Compressive Strength Based on Net Area, lb. per sq. in.			
			End Construction		Side Construction	
	Mean of 5 Tests	Individual Maximum	Mean of 5 Tests	Individual Minimum	Mean of 5 Tests	Individual Minimum
Hard	12 or less	15	4600 or more	3000	2400 or more	1700
Medium	16 or less	19	3200 or more	2250	1600 or more	1100
Soft	25 or less	28	2000 or more	1400	1200 or more	850

[b] As different types of clay are used in the manufacture of tile, color cannot be taken as indicative of classification."

Section 3 (*a*) *Weights.*—In the table of weights it is recommended that a 4-cell 6 by 12 by 12-in. unit weighing 25 lb. be added. It is also recommended that the weight of the 4-cell 10 by 12 by 12-in. unit be changed from 36 to 35 lb. These revisions are intended to make the values conform with present manufacturing practice.

Section 20. Capping.—Change the first sentence of Paragraph (*a*) to read as follows by the omission of the words in brackets:

> "Bearing surfaces of the test samples and portions adjoining them which are liable to absorb water from the plastic capping shall be coated with [one coat of] shellac and allowed to dry."

Change the last sentence of Paragraph (*c*) from its present form: namely,

> "Any other method of capping which produces equally satisfactory results may be used."

to read as follows:

> "If the tile so capped fail to pass specification requirements on the score of strength, they shall be retested with portland-cement-gypsum caps aged not less than three days."

Section 22. Position of Tile.—Change from its present form: namely,

> "In the tests, the tile shall be loaded in the direction in which they receive the principal stress in the structure."

to read as follows:

> "All tile shall be tested in a position such that the load is applied in the same direction as in service."

The committee recommends that the specifications as revised be adopted as standard.

The recommendations contained in this report have been submitted to letter ballot with the following results:

Items	Affirmative	Negative	Not Voting
I. PROPOSED REVISIONS OF STANDARD			
Standard Specifications and Tests for Hollow Burned-Clay Load-Bearing Wall Tile (C 34 - 26)	19	0	4
II. TENTATIVE STANDARD REVISED AND ADVANCED TO STANDARD			
Tentative Specifications and Tests for Hollow Burned-Clay Floor Tile (C 57 - 26 T)	19	0	4
III. PROPOSED REVISIONS OF EXISTING TENTATIVE STANDARD			
Tentative Specifications and Tests for Hollow Burned-Clay Fireproofing, Partition and Furring Tile (C 56 - 26 T)	19	0	4

This report has been submitted to letter ballot of the committee, which consists of 24 members, of whom 22 have voted affirmatively, none negatively, and 2 have refrained from voting.

Respectfully submitted on behalf of the committee,

D. E. PARSONS,
Chairman.

H. D. FOSTER,
Secretary.

EDITORIAL NOTE

The proposed revisions of the Standard Specifications and Tests for Hollow Burned-Clay Load-Bearing Wall Tile were approved at the annual meeting by a nine-tenths vote and were subsequently adopted by letter ballot of the Society on September 1, 1927. The specifications as revised appear in the 1927 Book of A.S.T.M. Standards, Part II.

The Tentative Specifications and Tests for Hollow Burned-Clay Floor Tile, revised as recommended by the committee, were approved at the annual meeting and subsequently adopted by letter ballot of the Society on September 1, 1927, and appear in the 1927 Book of A.S.T.M. Standards, Part II.

The proposed revisions of the Tentative Specifications and Tests for Hollow Burned-Clay Fireproofing, Partition and Furring Tile, were accepted. The specifications as revised appear on page 841.

REPORT OF COMMITTEE C-11
ON
GYPSUM

Committee C-11 has held three meetings since presenting its last report. They were held at Chicago, Ill., on November 11 and 12, 1926; at Philadelphia, Pa., on March 15 and 16, 1927; and at French Lick, Ind., in conjunction with the June, 1927, meeting of the Society.

In the death of Ira H. Woolson, Committee C-11 has experienced a keen loss, for his participation from its beginning was always active, always understanding, and more than once has helped the committee safely through difficult grounds.

Aside from recommendations in this report the committee is very active in the development of specifications for structural gypsum and expects considerable expression of its progress in this direction during the coming year.

The following recommendations are made to the Society, relative to the standards and tentative standards under the jurisdiction of Committee C-11:

Standard Methods of Testing Gypsum and Gypsum Products (C 26 - 23).[1] — Revisions of these standard methods were submitted in 1925 and have been published as tentative[2] for the past two years. It is now recommended that these revisions be advanced to standard, with the following modification in the proposed Section 23 (*c*), making the last sentence of this paragraph read as follows by the addition of the italicized words and figures and the omission of those in brackets:

> "When neat gypsum mortar is used for bedding and capping, the test may be conducted after the mortar has set, but not sooner than [one hour] *24 hours* after the sample has been capped."

Standard Specifications for Gypsum Plasters (C 28 - 21).[1] Revisions of these Standard specifications were submitted in 1926 and have been published as tentative[3] since then. These revisions contemplated incorporating in Sections 3, 6, 7, and 11, the provision that calcined gypsum should be calculated from the SO_3 content. It is recommended that this revision be modified by the addition of the chemical formula $CaSO_4 \cdot \frac{1}{2}H_2O$ after the word "gypsum" and that the revisions as modified be advanced to standard.

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[1] 1924 Book of A.S.T.M. Standards.

[2] *Proceedings*, Am. Soc. Testing Mats., Vol. 26, Part I, p. 1126 (1926).

[3] *Ibid.*, p. 1124.

Standard Specifications for Gypsum Partition Tile or Block (C 52 – 25).[1]—It is recommended that the revisions proposed in 1926 and published as tentative[2] since then be advanced to standard, without change.

Tentative Definitions of Terms Relating to the Gypsum Industry (C 11 – 26 T).[3]—It is recommended that the following definitions be accepted for publication as tentative:

> "*Gypsum Molding Plaster.*—A material consisting essentially of calcined gypsum for use in making interior embellishments, cornices, etc."
>
> "*Gypsum Pottery Plaster.*—A material consisting essentially of calcined gypsum for use in making pottery, terra cotta and other ceramic molds."
>
> "*Keene's Cement.*—Anhydrous calcined gypsum, the set of which is accelerated by the addition of other materials."

The addition of the following members to the committee has not disturbed the balance of producer and non-producer membership:

U. S. Bureau of Mines, New Brunswick, N. J., represented by Oliver Bowles (non-producer).

Atlantic Gypsum Products Co., Portsmouth, N. H., represented by H. C. Raynes (producer).

The recommendations appearing in this report have been submitted to letter ballot of the committee with the following result:

Items	Affirmative	Negative	Not Voting
I. REVISIONS OF EXISTING STANDARDS ADVANCED TO STANDARD			
Standard Specifications for Gypsum Plasters (C 28 – 26)	28	0	4
Standard Specifications for Gypsum Partition Tile or Block (C 52 – 25)	26	0	6
Standard Methods of Testing Gypsum and Gypsum Products (C 26 – 23)	27	0	5
II. PROPOSED NEW TENTATIVE STANDARDS			
Definitions of the Terms Gypsum Molding Plaster, Gypsum Pottery Plaster, and Keene's Cement	28	0	4

This report has been submitted to letter ballot of the committee, which consists of 32 members, of whom 30 have voted affirmatively, none negatively, and 2 have refrained from voting.

Respectfully submitted on behalf of the committee,

J. W. GINDER,
Chairman.

H. E. BROOKBY,
Vice-Chairman.

H. J. SCHWEIM,
Secretary.

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[1] A. S.T.M. Standards Adopted in 1925.

[2] *Proceedings*, Am. Soc. Testing Mats., Vol. 26, Part I, p. 1125 (1926).

[3] *Proceedings*, Am. Soc. Testing Mats., Vol. 26, Part I, p. 786 (1926); also 1926 Book of A.S.T.M. Tentative Standards, p. 313.

EDITORIAL NOTE

The tentative revisions of the Standard Specifications for Gypsum Plasters; for Gypsum Partition Tile or Block; and of the Methods of Testing Gypsum and Gypsum Products, amended as recommended by the committee, were approved at the annual meeting and subsequently adopted by letter ballot of the Society on September 1, 1927. The specifications and methods as revised appear in the 1927 Book of A.S.T.M. Standards, Part II.

The proposed tentative definitions of the terms gypsum molding plaster, gypsum pottery plaster, and Keene's cement were accepted for publication as tentative, to be added to the present Tentative Definitions of Terms Relating to the Gypsum Industry. The definitions appear on page 793.

REPORT OF COMMITTEE D-1

ON

PRESERVATIVE COATINGS FOR STRUCTURAL MATERIALS

Committee D-1 on Preservative Coatings for Structural Materials held a meeting in Richmond, Va., on Thursday, April 14, 1927. During the past year there has been one resignation and thirteen new members have been elected, making a total membership at the present time of 170. Most of the committee's members have been very active during the past year which has resulted in the recommendation of a number of new standards and the revision of several others.

The activities of the various committees are presented as follows:

Sub-Committee III on Testing of Paint Vehicles, H. A. Gardner, chairman, recommends that the Tentative Specifications for Tung Oil (D 12 - 25 T) remain as tentative.

Sub-Committee V on Linseed Oil, R. D. Bonney, chairman, in its report appended hereto submits the results of analyses of many samples of linseed oil tested by members of the sub-committee. The sub-committee recommends the withdrawal of the Standard Specifications for Purity of Boiled Linseed Oil from North American Seed (D 11 - 15) and the Tentative Specifications for Purity of Boiled Linseed Oil from South American Seed (D 78 - 21 T) and the submission of new Tentative Specifications for Boiled Linseed Oil. It further makes the recommendation that the present Tentative Specifications for Raw Linseed Oil (D 234 - 26 T) be revised and advanced to standard.

Sub-Committee VIII on Methods of Analysis of Paint Materials, F. W. Smither, chairman, in its report appended hereto recommends a revision of the Standard Method of Test for Specific Gravity of Pigments (D 153 - 24), including the incorporation of revised Methods D 238 - 26 T, and slight revisions in various standard methods of analysis to bring them up to date and to include references to certain recently adopted standard methods of test.

On the recommendation of Sub-Committee XII on Turpentine, F. P. Veitch, chairman, the following slight revisions are recommended in the Tentative Specifications for Destructively Distilled Wood Turpentine (D 236 - 26 T):[1]

Section 6.—In the table of requirements, following the words "Refractive index at 20° C.," insert the words "D line."

The specifications as revised are recommended for advancement to standard.

Sub-Committee XIII on Shellac, J. W. Paisley, chairman, in its report appended hereto recommends that the Tentative Specifications for Orange Shellac (D 237 - 26 T) be advanced to standard. It presents revisions of the Tentative Methods of Testing Shellac Varnish (D 214 - 26 T). It further submits a new Tentative Method of Test for Determination of Wax in Shellac ("Machine Made" and Dry-Bleached Refined Shellac) to be added when adopted to the present Standard Methods of Testing Shellac (D 29 - 25).

Sub-Committee XV on Specifications for Pigments Dry and in Oil when Marketed in that Form, H. E. Smith, chairman, is recommending revisions of the Standard Specifications for Ocher (D 85 - 24) as presented in its report appended hereto, the revision and advancement to standard of Tentative Specifications for Iron Oxide and Iron Hydroxide (D 84 - 25 T), for Chrome Yellow (D 211 - 26 T), for Pure Chrome Green (D 212 - 26 T), and for Reduced Chrome Green (D 213 - 26 T). It proposes new Tentative Specifications for Prussian Blue, for Ultramarine Blue, for Chrome Oxide Green, for Commercial Para Red, for Titanium Barium Pigment, for Aluminum Bronze Powder and for Gold Bronze Powder.

Sub-Committee XXIII on Anti-Fouling Paints, under the chairmanship of A. M. Muckenfuss, has continued its investigations of the past few years to arrive at satisfactory anti-corrosive and anti-fouling paints for the painting of ship bottoms. Its more recent investigations are reported upon in the report of the sub-committee appended hereto.

Sub-Committee XXV on Cellulose Ester Coatings, W. R. Fuller, chairman, is presenting new Tentative Methods for Sampling and Testing Lacquer Solvents and Diluents, as appended to the sub-committee's report.[2]

The recommendations presented by the sub-committees are concurred in by Committee D-1 and are presented herewith as its recommendations. The committee asks that these recommendations be approved, including the revisions of standards recommended to become effective immediately, as recommended by Sub-Committees VIII and XV, requiring a nine-tenths vote of the Society.

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 26, Part I, p. 795 (1926); also 1926 Book of A.S.T.M. Tentative Standards, p. 344.

[2] See p. 870.—ED.

The recommendations have been submitted to letter ballot of the committee and 42 replies have been received. The results of the ballot are as follows:

Items	Affirmative	Negative	Not Voting
I. PROPOSED NEW TENTATIVE STANDARDS			
Specifications for Boiled Linseed Oil	32	0	10
Specifications for Prussian Blue	25	1	16
Specifications for Ultramarine Blue	25	1	16
Specifications for Chrome Oxide Green	25	1	16
Specifications for Commercial Para Red	24	1	17
Specifications for Titanium Barium Pigment	30	1	11
Specifications for Aluminum Bronze Powder	26	1	15
Specifications for Gold Bronze Powder	26	1	15
Methods of Sampling and Testing Lacquer Solvents and Diluents	29	0	13
Method of Test for Determination of Wax in Shellac	28	0	14
II. TENTATIVE STANDARDS ADVANCED TO STANDARD			
Tentative Specifications for Raw Linseed Oil (D 234 - 26 T), as revised	31	1	10
Tentative Specifications for Destructively Distilled Wood Turpentine (D 236 - 26 T), as revised	27	0	15
Tentative Specifications for Orange Shellac (D 237 - 26 T)	26	0	16
Tentative Specifications for Iron Oxide and Iron Hydroxide (D 84 - 25 T), as revised	26	1	15
Tentative Specifications for Chrome Yellow (D 211 - 26 T), as revised	26	1	15
Tentative Specifications for Pure Chrome Green (D 212 - 26 T), as revised	26	1	15
Tentative Specifications for Reduced Chrome Green (D 213 - 26 T), as revised	26	1	15
Tentative Method of Test for Specific Gravity of Pigments (D 238 - 26 T), as revised	27	0	15
III. REVISIONS OF EXISTING STANDARDS			
Standard Specifications for Ocher (D 85 - 24)	26	1	15
Standard Methods of Test for Specific Gravity of Pigments (D 153 - 24)	31	0	11
Standard Methods of Routine Analysis of White Pigments (D 34 - 17)	31	0	11
Standard Methods of Routine Analysis of Red Lead (D 49 - 18)	31	0	11
Standard Methods of Routine Analysis of Yellow, Orange, Red, and Brown Pigments Containing Iron and Manganese (D 50 - 18)	31	0	11
Standard Methods of Routine Analysis of Yellow and Orange Pigments Containing Chromium Compounds, Blue Pigments and Chrome Green (D 126 - 23)	31	0	11
Standard Methods of Routine Analysis of Titanium Pigments (D 186 - 25)	30	0	12
IV. REVISION OF TENTATIVE STANDARDS			
Tentative Methods of Testing Shellac Varnish (D 214 - 26 T)	28	0	14
Tentative Methods of Routine Analysis of White Linseed Oil Paints (D 215 - 25 T)	28	1	13
V. WITHDRAWAL OF STANDARDS AND TENTATIVE STANDARDS			
Standard Specifications for Purity of Boiled Linseed Oil from North American Seed (D 11 - 15)	32	0	10
Tentative Specifications for Purity of Boiled Linseed Oil from South American Seed (D 78 - 21 T)	32	0	10

This report has been submitted to letter ballot of the committee, which consists of 170 members, of whom 42 have voted affirmatively, none negatively, and 128 have refrained from voting.

Respectfully submitted on behalf of the committee,

ALLEN ROGERS,
Chairman.

R. L. HALLETT,
Secretary.

EDITORIAL NOTE

The following tentative specifications and method of test were approved at the annual meeting, revised as recommended by the committee, and subsequently adopted by letter ballot of the Society on September 1, 1927: for Destructively Distilled Wood Turpentine; for Iron Oxide and Iron Hydroxide; for Chrome Yellow; for Pure Chrome Green; for Reduced Chrome Green; and Method of Test for Specific Gravity of Pigments. The specifications and method as revised appear in the 1927 Book of A.S.T.M. Standards, Part II.

The Tentative Specifications for Raw Linseed Oil, revised as recommended by the committee, were approved at the annual meeting and subsequently adopted by letter ballot of the Society on September 1, 1927, for adoption as standard to supersede the present Standard Specifications for Purity of Raw Linseed Oil from North American Seed, and appear in the 1927 Book of A.S.T.M. Standards, Part II. The standard specifications were withdrawn. The Tentative Specifications for Orange Shellac were approved at the annual meeting and subsequently adopted by letter ballot of the Society on September 1, 1927. They appear in the 1927 Book of A.S.T.M. Standards, Part II.

The proposed revisions of the following standard specifications and methods of test were approved at the annual meeting by a nine-tenths vote and were subsequently adopted by letter ballot of the Society on September 1, 1927: for Ocher; Method of Test for Specific Gravity of Pigments; of Routine Analysis of White Pigments; of Routine Analysis of Dry Red Lead; of Routine Analysis of Yellow, Orange, Red, and Brown Pigments Containing Iron and Manganese; of Routine Analysis of Yellow and Orange Pigments Containing Chromium Compounds, Blue Pigments and Chrome Green; and of Routine Analysis of Titanium Pigments. The specifications and methods as revised appear in the 1927 Book of A.S.T.M. Standards, Part II.

The proposed revisions of the Tentative Methods of Testing Shellac Varnish; and of Routine Analysis of White Linseed Oil Paints were accepted. The methods as revised appear on pages 862 and 873, respectively.

The proposed Tentative Specifications for Prussian Blue; for Ultramarine Blue; for Chrome Oxide Green; for Commercial Para Red; for Titanium Barium Pigment; for Aluminum Bronze Powder for Paints; for Gold Bronze Powder; and Methods of Sampling and Testing Lacquer Solvents and Diluents, were accepted for publication as tentative and appear on pages 850 to 861 and page 870. The proposed Tentative Specifications for Boiled Linseed Oil were accepted for publication as tentative to replace the present Standard Specifications for Purity of Boiled Linseed Oil from North American Seed and the Tentative Specifications for Purity of Boiled Linseed Oil from South American Seed, and appear on page 846. The standard and tentative specifications were withdrawn. The proposed Method of Test for Determination of Wax in Shellac ("Machine-Made" and Dry-Bleached Refined Shellac) was accepted for publication as tentative as a revision of the Standard Methods of Testing Shellac, and appears on page 869.

REPORT OF SUB-COMMITTEE V ON LINSEED OIL

Raw Linseed Oil

The Federal Specifications Board has issued a revision of the United States Government Master Specifications for linseed oil (raw and boiled), which differs in several particulars from the Society's Tentative Specifications for Raw Linseed Oil (D 234 – 26 T)[1] offered by the sub-committee and approved at the 1926 annual meeting of the Society. The principal difference lies in the fact that some of the requirements for raw linseed oil have been lowered. The minimum specific gravity is placed at 0.9300 in place of 0.931; the maximum acid value at 5.5 in place of 4.0; and the minimum iodine value (Wijs) at 175.0 in place of 180.0.

In order to determine the advisability of making similar alterations in the tentative specifications, requests were sent to the members of the sub-committee asking that they forward the results of their routine tests on linseed oil for tabulation. These tables would show in some degree the percentage of commercial linseed oil deliveries which are falling outside the present limits of the specifications. Reports were requested on specific gravity, acid value, iodine value (Wijs), foots test on heated oil and foots test on chilled oil. Many members have included the quantity represented. The large majority of results given in the tables are for car lots, while others are for periodical tests on larger quantities.

The members who have complied with this request are as follows:

J. B. Davis, Standard Textile Products Co., Buchanan, N. Y.
F. S. Deacon, Congoleum-Nairn Inc., Kearny, N. J.
W. H. Eastman, Wm. O. Goodrich Co., Milwaukee, Wis.
E. W. Fasig, The Lowe Bros. Co., Dayton, Ohio.
D. V. Gregory, E. I. Du Pont de Nemours Co. Inc., Wilmington, Del.
R. L. Hallett, National Lead Co., Brooklyn, N. Y.
K. A. Horn, Congoleum-Nairn Inc., Marcus Hook, Pa.
R. B. Rohrer, Armstrong Cork Co., Lancaster, Pa.
S. O. Sorenson, Archer-Daniels-Midland Co., Minneapolis, Minn.

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 26, Part I, p. 788 (1926); also 1926 Book of A.S.T.M. Tentative Standards, p. 336.

TABLE I.—RESULTS OF SPECIFIC GRAVITY TESTS ON DELIVERIES OF RAW LINSEED OIL.

Requirements, A.S.T.M. Specifications D 234 - 26 T: Minimum, 0.931; Maximum, 0.935.

Specific Gravity at 60° F.	Consumer A	Consumer B	Consumer C	Con sumer D	Producer A	Consumer E	Consumer F	Producer B	Consumer G	Consumer H	Totals	Per Cent of Total
929	..	..	..	..	..	..	..	..	..	..	0	0.0
930	..	..	..	..	2	..	..	None	..	..	2	0.6
931[a]	..	..	1	..	..	5	Number	..	..	..	6	1.9
932	1	1	2	1	..	18	not	..	3	29	55	17.4
933	10	12	7	22	14	8	reported	Min., 0.933	7	7	87	27.4
934	17	..	2	19	29	27	..	Av., 0.934	10	..	104	32.9
935[b]	26	2	..	2	1	16	..	Max., 0.935	..	..	47	14.8
936	12	..	..	..	1	..	8 per	..	..	..	13	4.1
937	1	..	..	..	1	..	cent over	..	..	..	2	0.6
938	..	..	..	1	..	..	0.935	..	..	..	1	0.3
Total	67	15	12	45	48	74	..	..	20	36	317	100.0

[a] Specified minimum, A.S.T.M. Tentative Specifications for Raw Linseed Oil (D 245 - 26 T).

[b] Specified maximum, A.S.T.M. Tentative Specifications for Raw Linseed Oil (D 245 - 26 T).

TABLE II.—RESULTS OF CHILLED OIL FOOTS TESTS ON DELIVERIES OF RAW LINSEED OIL.

Requirements, A.S.T.M. Tentative Specifications D 234 - 26 T: Maximum, 4.0.

Foots	Consumer B	Consumer E	Producer A	Consumer H	Total	Per Cent of Total
0.2	..	..	1	..	1	1.2
0.4	..	1	..	1	2	2.4
0.6	..	..	..	..	0	....
0.8	..	4	3	2	9	10.8
1.0	..	1	5	1	7	8.4
1.2	1	6	2	..	9	10.8
1.4	..	1	3	..	4	4.8
1.6	..	3	4	..	8	9.4
1.8	..	..	1	..	1	1.2
2.0	..	5	4	..	9	10.8
2.2	..	..	..	..	0	....
2.4	..	..	2	..	2	2.4
2.6	..	..	..	..	..	....
2.8	1	5	1	..	7	8.4
3.0	..	1	..	..	1	1.2
3.2	..	..	8	..	8	9.4
3.4	..	..	1	..	1	1.2
3.6	..	1	2	..	3	3.6
3.8	..	..	1	..	1	1.2
4.0[a]	1	1	4	..	6	7.2
4.4	..	..	2	..	2	2.4
5.0	..	..	2	..	2	2.4
7.6	..	..	1	..	1	1.2
Total	3	29	46	5	84	100.4

[a] Specified maximum, A.S.T.M. Tentative Specifications for Raw Linseed Oil (D 234 - 26 T).

TABLE III.—RESULTS OF HEATED OIL FOOTS TESTS ON DELIVERIES OF RAW LINSEED OIL.

Requirements, A.S.T.M. Tentative Specifications D 234 - 26 T: Maximum, 1.0.

Foots	Consumer B	Consumer E	Producer A	Consumer G	Consumer H	Total	Per Cent of Total
0.0	..	..	1	..	..	1	1.0
0.2	..	6	10	13	3	32	31.0
0.4	1	7	15	7	1	31	30.1
0.6	..	7	4	..	..	11	10.7
0.8	2	8	11	..	..	21	20.4
1.0[a]	..	1	4	..	..	5	4.8
1.2	..	..	1	..	..	1	1.0
1.4	..	..	..	..	..	..	....
1.6	..	1	..	..	..	1	1.0
Total	3	30	46	20	4	103	100.0

[a] Specified maximum, A.S.T.M. Tentative Specifications for Raw Linseed Oil (D 234 - 26 T).

TABLE IV.—RESULTS OF IODINE VALUE TESTS ON DELIVERIES OF RAW LINSEED OIL.

Requirements, A.S.T.M. Specifications D 234 - 26 T: Minimum, 180.

Iodine Number, Wijs	Consumer A	Consumer B[a]	Consumer C[c]	Consumer D[a]	Producer A	Consumer E	Producer B	Consumer F[b]	Consumer G	Consumer H	Totals	Per Cent of Total	
174	..	..	1	..	..	..	..	0.7	1	..	2	0.7	9.6
175	..	..	..	..	2	..	..	per cent	..	..	2	0.7	
176	..	..	..	1	..	..	..	of cars	..	..	1	0.3	
177	..	..	..	..	2	..	..	below	..	3	5	1.7	
178	1	..	3	..	..	..	Min., 178	175	3	4	11	3.8	
179	2	..	..	..	..	..	..		1	4	7	2.4	
180[c]	4	..	2[b]	..	2	2	96	9.35	..	6	16	5.5	
181	..	..	3	1	2	8	per cent	per cent	..	4	18	6.2	
182	..	1	8	3	6	11	..	of cars	3	7	39	13.4	
183	2	1	1	9	7	11	..	below	2	3	36	12.4	
184	2	6	..	11	11	4	..	180	3	1	38	13.1	
185	..	4	..	5	9	6	180 or		..	3	27	9.3	
186	4	1	..	7	6	3	over		..	..	21	7.2	
187	..	..	2	8	..	6	..		..	..	16	5.5	
188	3	..	..	5	1	2	..	5.9	3	1	15	5.2	
189	..	..	..	3	..	3	Max., 189	per cent	3	..	9	3.1	
190	..	..	..	4	..	3	..	of cars	..	..	7	2.4	
191	1	..	..	..	..	4	..	over 188	..	..	5	1.7	
192	..	..	1	..	..	3	..		..	..	4	1.4	
193	..	..	..	..	..	2	..		1	..	3	1.0	
194	..	..	..	..	..	2	..		..	..	2	0.7	
195	..	1	..	1	..	2	..		..	..	4	1.4	
196	..	..	..	..	..	..	..		..	..	0	0.0	
197	..	..	..	..	..	1	..		..	..	1	0.3	
198	..	1	..	..	..	1	..		..	..	2	0.7	
Total	19	15	21	58	48	74	..		20	36	291	100.0	

[a] Calculated from Hanus Values.
[b] June to November, 1926.
[c] Specified minimum, A.S.T.M. Tentative Specifications for Raw Linseed Oil (D 234 - 26 T)

F. E. Walker, Congoleum-Nairn Inc., Camden, N. J.
P. H. Walker and L. L. Steele, U. S. Bureau of standards, Washington, D. C.

Tables I to V and Figures 1 to 5 give a resumé of the information sent in.

Acid Number.—Of the 327 samples tested on deliveries 2.7 per cent failed to meet the requirements of Tentative Specifications D 234 - 26 T. The committee does not believe that an increase in the maximum requirement is necessary to cover the few deliveries which fall outside the specifications. It is believed that an oil with an acid number greater than 4.0 will for many purposes not give uniform results when used in formulas based on normal linseed oil.

Table V.—Results of Acid Value Tests on Deliveries of Raw Linseed Oil.

Requirements, A.S.T.M. Specifications D 234 - 26 T: Maximum, 4.0.

Acid Number	Consumer A	Consumer B	Consumer C	Consumer D	Producer B	Producer A	Consumer E	Consumer F[a]	Consumer G	Consumer H	Totals	Per Cent of Total
0.6 - 1.0....	..	..	..	..	..	..	..	..	..	..	..	....
1.1 - 1.5....	..	..	..	..	Min., 1.2	..	4	..	..	1	5	1.5
1.6 - 2.0....	24	2	6	3	Av., 1.6	2	5	Number not reported	7	6	55	16.9
2.1 - 2.5....	15	5	7	12	Max., 2.2	15	19		5	11	89	27.1
2.6 - 3.0....	13	6	2	9	..	6	19		4	7	66	20.2
3.1 - 3.5....	12	0	4	13	..	13	16	..	3	9	70	21.4
3.6 - 4.0[b]...	3	1	0	5	..	11	10	..	1	2	33	10.2
4.1 - 4.5....	1	1	2	1	..	1	..	1.1 per cent above 4.0 5 per cent above 5.5	..	..	6	1.8
4.6 - 5.0....	..	..	..	2	..	..	1		..	..	3	0.9
5.1 - 5.5....	..	..	..	..	..	..	..		..	..	..	0.0
Total........	68	15	21	45	..	48	74	..	20	36	327	100.0

[a] June to November 26.

[b] Specified maximum, A.S.T.M. Tentative Specifications for Raw Linseed Oil (D 234 - 26 T).

Iodine value.—The present minimum requirement for iodine value of 180.0 Wijs appears to be slightly higher than necessary, as 9.6 per cent of the samples tested were found to be below this value. The sub-committee recomends that this value be lowered to 177.0. If this value be considered the minimum, then only 1.7 per cent of the samples fail to pass. In view of these results, any further reduction in the iodine value (to 175.0) is not justified. We believe an iodine value of 177.0 will not be difficult for the crusher to obtain, provided he does not use seed of inferior quality or employ improper production methods, furthermore, this value will insure the consumer of good quality.

Specific Gravity.—The results obtained from the tabulation of raw linseed oil deliveries show that 94.4 per cent of the 317 samples

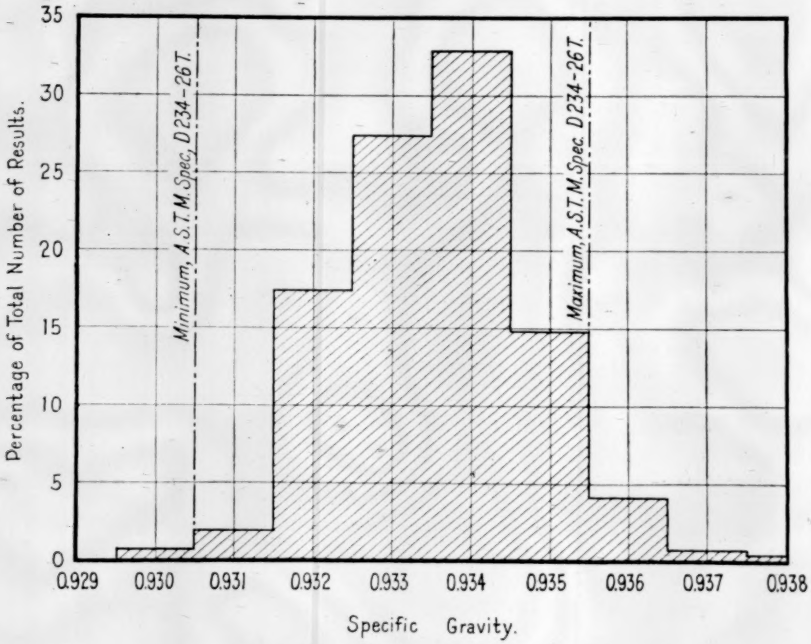

FIG. 1.—Results of Specific Gravity Tests on Deliveries of Raw Linseed Oil.

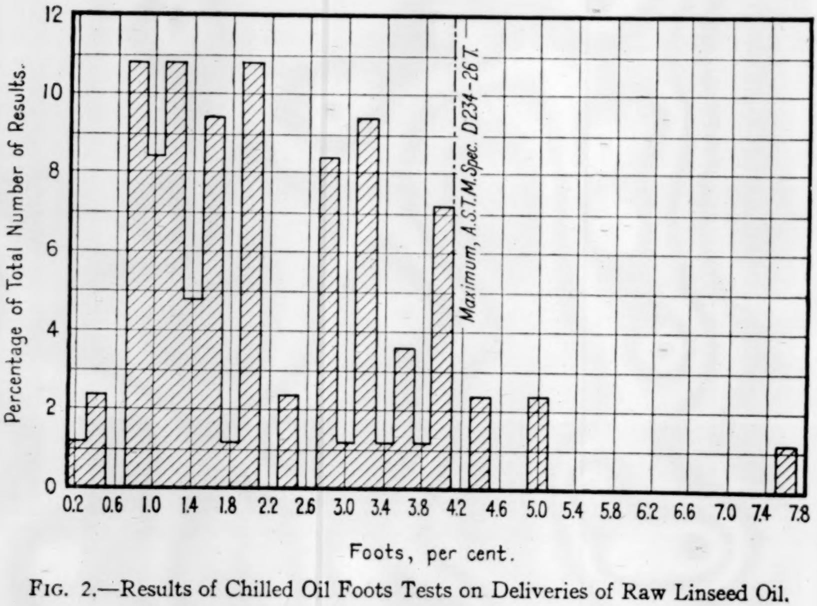

FIG. 2.—Results of Chilled Oil Foots Tests on Deliveries of Raw Linseed Oil.

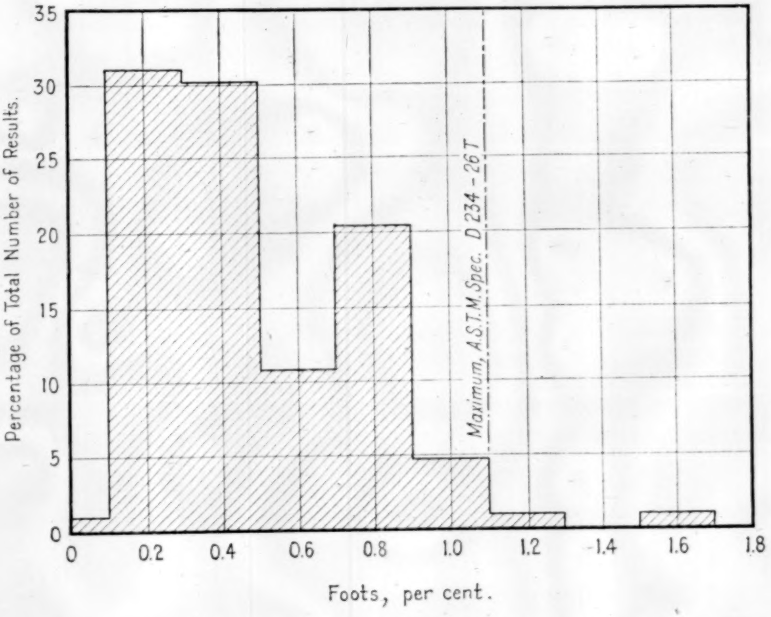

FIG. 3.—Results of Heated Oil Foots Tests on Deliveries of Raw Linseed Oil.

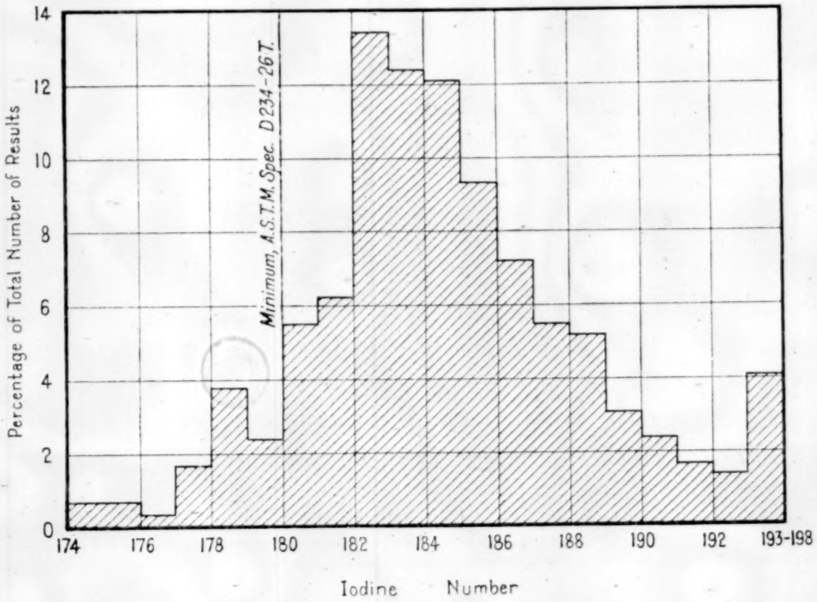

FIG. 4.—Results of Iodine Value Tests on Deliveries of Raw Linseed Oil.

tested will meet the requirements of the Tentative Specifications D 234 - 26 T. Only 0.6 per cent of the values obtained were found to be below the minimum limit of 0.931. The results would tend to indicate that if any change were to be made, an increase of the maximum limit to 0.936 would be of greater value than a decrease in the minimum limit. This change is recommended.

Foots (Heated Oil).—All samples with the exception of 2 per cent are satisfactory under the specified maximum of present tentative specifications. The sub-committee recommends no change in the maximum limit for foots on heated oil.

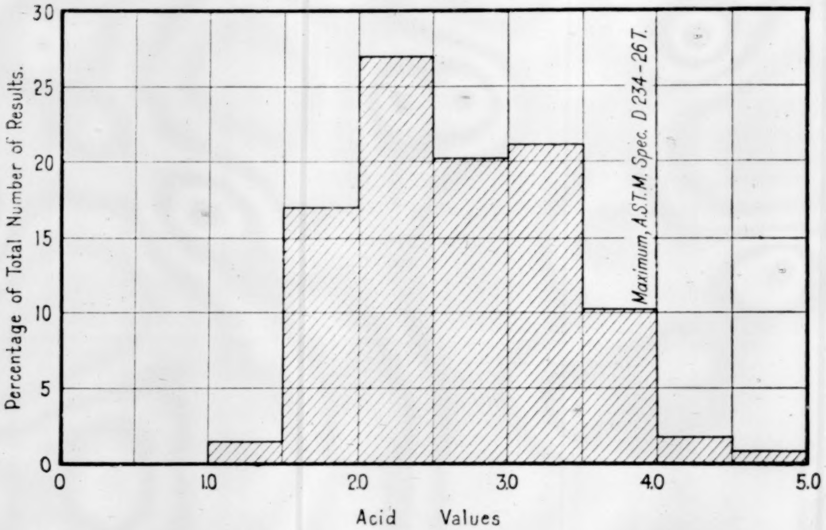

FIG. 5.—Results of Acid Value Tests on Deliveries of Raw Linseed Oil.

Foots (Chilled Oil).—The committee recommends no change in the present specified maximum of 4.0 for foots test on chilled oil. In view of the results of the tabulation, it would appear that any increase would be of little value.

Foots.—

The report of the sub-committee for 1926[1] discussed at length the results of foots and ash determinations on three special oils distributed to the various members for cooperative work. While these tests in themselves were not wholly satisfactory, they led to the development of the heated and chilled foots tests, which give considerable promise. The opinion of the sub-committee at that time was that the most satisfactory measure of the mucilaginous matter was a foots determination on a sample of the oil which had been previously heated to 65° C. The same determination on a sample of oil, which had been chilled to 0° C. gave a measure of the mucilaginous matter plus solidifiable fats. The maximum limits for foots determined by these methods were 1.0 and 4.0, respectively. These recommendations were incorporated in the Tentative Specifications for Raw Linseed Oil (D 234 - 26 T).

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 26, Part I, p. 315 (1926.)

TABLE VI.—"FOOTS" AND ASH DETERMINATIONS ON SIX SAMPLES OF RAW LINSEED OIL.

All values are in terms of per cent.

Sample No.	Test No.	Observer							Maximum	Minimum	Average
		No. 1	No. 2	No. 3	No. 4	No. 5	No. 6	No. 7			
63......	1.......	0.2	0.1	trace	0.0	0.0	0.1	0.2	0.20	0.00	0.08
	2.......	1.4	0.7	1.2	1.0	0.4	0.6	2.6	2.6	0.4	1.12
	3.......	0.127	0.156	0.100	0.127	0.134	0.138	0.110	0.156	0.100	0.127
64......	1.......	3.3	1.3	4.8	3.4	3.6	3.3	4.8	4.8	1.3	3.49
	2.......	6.1	4.8	5.6	5.9	4.8	3.6	5.6	6.1	3.6	5.2
	3.......	0.161	0.154	0.070	0.140	0.153	0.141	0.140	0.161	0.070	0.137
65......	1.......	0.6	0.4	0.4	0.2	0.4	0.3	1.4	1.4	0.2	0.53
	2.......	3.8	2.0	3.2	2.4	1.2	1.9	2.7	3.8	1.2	2.4
	3.......	0.158	0.130	0.110	0.111	0.114	0.123	0.110	0.158	0.110	0.122
66......	1.......	0.7	1.0	0.8	0.8	0.8	1.0	2.2	2.2	0.7	1.04
	2.......	2.0	3.3	1.2	2.0	2.0	2.1	3.0	3.3	1.2	2.23
	3.......	0.175	0.180	0.150	0.155	0.168	0.180	0.130	0.180	0.130	0.163
67......	1.......	0.9	0.6	0.6	0.8	0.8	0.7	1.4	1.4	0.6	0.83
	2.......	0.7	0.7	0.8	0.8	0.8	0.7	1.4	1.4	0.7	0.85
	2.......	0.144	0.128	0.110	0.136	0.145	0.128	0.120	0.145	0.110	0.130
68......	1.......	17.0	10.8	0.8	17.2	13.0	(15.0) 8.8	10.8	17.2	8.8	12.9
	2.......	17.6	18.4	1.2	18.0	20.0	(18.0) 10.0	9.6	20.0	9.6	15.6
	3.......	0.353	0.336	0.140	0.333	0.349	0.403	0.330	0.403	0.140	0.320

Test No. 1.—Foots, Heated Oil, see text.
Test No. 2.—Foots, Chilled Oil, see text.
Test No. 3.—Determination of Ash, see text.

Cooperative work during the past year has been carried out by the sub-committee on these tests. The Ash determination has also been included in this work. Six samples of raw linseed oil, numbered 63 to 68, inclusive, were sent out to members, with the request that determinations be made on them, according to the following methods. These directions are identical with those of the Tentative Specification D 234 - 26 T.

Test No. 1.—Heat a portion of the oil to 150° F., hold it at that temperature for 10 minutes, then cool it to room temperature (70–80° F.). Subject the sample to the foots test described in A.S.T.M. Specifications D 51 - 18 T.

Test No. 2.—Heat a portion to 150° F., hold it at that temperature for 10 minutes; then place it in a clean dry bottle, stopper tightly, and place in a cracked ice water mixture (32° F.) for exactly two hours. At the end of this time, place the bottle for exactly thirty minutes in a water bath at 77° F., then subject it promptly to the foots test described in A.S.T.M. Specifications D 51 – 18 T.

Test No. 3.—Ash Test.—Ignite and weigh to an accuracy of 0.001 g., a porcelain crucible or small evaporating dish, having a capacity of about 50 cc. Into this container weigh about 25 g. of linseed oil. Add 3 drops of concentrated sulfuric acid. Heat the oil over a gas burner carefully to the fire point, ignite the oil, remove the burner and allow the oil to burn quietly as long as possible. Proceed carefully in this way, avoiding excessive foaming and renewing heat only when the oil has ceased to burn. When all foaming has ceased, apply the full flame of the burner until all the carbon has been burned and the ash is uncontaminated by black particles. Cool the dish in a desiccator, weigh to an accuracy of 0.001 g., calculate the increase in weight as a percentage of ash present in the oil.

The following observers have reported on the samples:

A. E. Clarke, Congoleum-Nairn Inc., Kearny, N. J.
J. B. Davis, Standard Textile Products Co., Buchanan, N. Y.
W. H. Eastman, Wm. O. Goodrich Co., Milwaukee, Wis.
D. V. Gregory, E. I. Du Pont de Nemours Co., Inc., Wilmington, Del.
R. B. Rohrer, Armstrong Cork Co., Lancaster, Pa.
S. O. Sorensen, Archer-Daniels-Midland Co., Minneapolis, Minn.
C. G. Wortz, Congoleum-Nairn Inc., Marcus Hook, Pa.

Table VI shows the results obtained by these cooperative tests.

A comparison of the results in Table VI, bearing in mind the basic inaccuracies of the method, will indicate that the agreement in the majority of cases is very good. In fact, if one or possibly two of the results of tests Nos. 1 and 2 on each oil be disregarded as obviously incorrect, the remainder of the results may be said to check very well. Sample No. 68, the percentage of foots being very high, has not shown concordant results, but in every case but one has shown the oil to meet the requirements of the specification.

With regard to the ash determination, some of the observers have reported results which are uniformly high, while others are uniformly low. This would indicate either that there is a tendency on the part of some to discontinue the heating too soon, or that the method of heating is slightly at fault.

Recommendations:

In accordance with the above, the sub-committee recommends that the Tentative Specifications for Raw Linseed Oil (D 234 – 26 T) be advanced to standard changing at the same time the minimum limit for iodine number from 180 to 177.0 and the maximum limit for specific gravity from 0.935 to 0.936.

BOILED LINSEED OIL

The society now has Standard Specifications for Purity of Boiled Linseed Oil from North American Seed (D 11 - 15)[1] and Tentative Specifications for Purity of Boiled Linseed Oil from South American Seed (D 78 - 21 T).[2] The Federal Specifications Board has a specification No. 475-*a* (revised March 5, 1927) for Oil-Boiled-Linseed.

The sub-committee has considered these existing specifications and has arrived at new specifications which in its judgment should supplant the existing A.S.T.M. standard and tentative specifications. These are modeled in a general way after Federal Specifications Board Specification 475-*a* (revised), but certain clauses deemed necessary by the Federal Departments but which seem undesirable for the use of this Society have been omitted. The conditions under which the drying test is conducted have also been defined more closely.

Accordingly, the sub-committee recommends the withdrawal of the existing standard and tentative specifications for boiled linseed oil and the acceptance for publication as tentative of the specifications appended hereto.[3]

Respectfully submitted on behalf of the sub-committee,

R. D. BONNEY,
Chairman.

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[1] 1924 Book of A.S.T.M. Standards.

[2] *Proceedings*, Am. Soc. Testing Mats., Vol. 21, p. 614 (1921); also 1926 Book of A.S.T.M. Tentative Standards, p. 341.

[3] See p. 846.—ED.

REPORT OF SUB-COMMITTEE VIII ON METHODS OF ANALYSIS OF PAINT MATERIALS

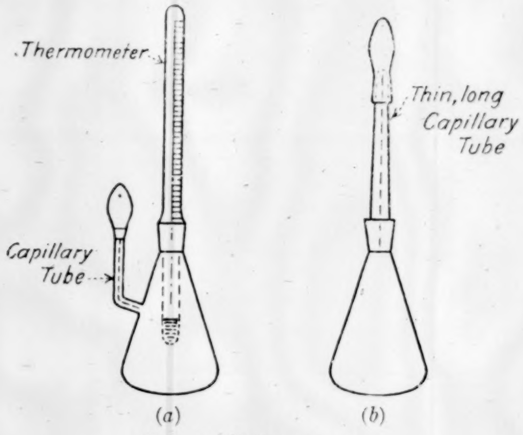
The sub-committee recommends that the following revisions be made in the Standard Method of Test for Specific Gravity of Pigments (D 153 - 24)[1] and that the method as revised be continued as standard:

Make the present method, Sections 1 to 10, a method for the routine testing of pigments, inserting a main heading to read as follows:

"Method *A:* For Routine Testing of Several Samples Simultaneously."

Change the first sentence in the note under Section 1 (*f*) to read as follows:

"The 'Hyvac' oil pump is satisfactory."



(*a*) (*b*)

FIG. 1.—Pyknometer.

Insert a new method, comprising Sections 11 and 12 to read as follows:

METHOD *B:* FOR TESTS REQUIRING HIGHEST ACCURACY.

APPARATUS

11. ***Apparatus.***—The apparatus shall consist of the following:

(*a*) A pyknometer as shown in Figs. 1 (*a*) or (*b*) having a capacity of 50 cc.

(*b*) A water bath consisting of a vessel filled with sufficient water to permit of only a very gradual rise in temperature and equipped with a stirring device, preferably air-blown.

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[1] 1924 Book of A.S.T.M. Standards.

(*c*) A glass bell jar with a two-hole rubber stopper. Into one hole of the stopper is fitted a separatory funnel with a well-ground stop-cock *c*, Fig. 2, and with the lower tube extending into the pyknometer (just below the opening of the side arm in Fig. 1 (*a*)). Into the other hole of the stopper is fitted a glass tube with a well-ground 3-way stop-cock, Fig. 2, the tube connecting with the vacuum pump *e*, Fig. 3. The bell jar rests on a sheet of rubber, cemented or vulcanized to a glass or iron plate. With stop-cock *c* closed and stop-cock *d* opened to the pump, the system shall withstand and maintain a vacuum.

NOTE.—A suitable desiccator may be substituted for the bell jar.

(*d*) A thermometer having a range of from 0 to 60° C. graduated in 0.1° C.

(*e*) A high vacuum pump *e*, Fig. 3.

(*f*) An open-tube manometer *f*, Fig. 3, as described in Section 1 (*c*).

(*g*) A storage bottle *h*, for kerosine or other wetting liquid.

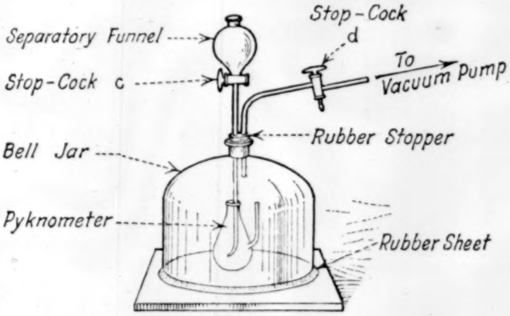

FIG. 2.

PROCEDURE

12. *Procedure.*—The pyknometer containing the weighed sample of dried pigment shall be placed under the bell jar. Close stop-cocks *c* and *d*, start the vacuum pump and gradually open stop-cock *d* to the pump. When the air has all been removed, with a vacuum of 1 mm. maintained, fill the separatory funnel with kerosine, close stop-cock *d*, and at once gradually open stop-cock *c*, adding sufficient kerosine to completely cover the pigment. Stop the pump and release suction at *d*. Finally fill the pyknometer with kerosine and complete the test as described in Sections 7 and 8.

NOTES

1. Before a new bell jar (or desiccator) is used for the first time, it shall be tested under a vacuum as described in Section 9.

2. Stop-cock *c* must be well-ground and should be lubricated with castor oil or glycerin. See precautions in Section 19 under Method *C* concerning the necessity of testing the system for leaks before making a determination.

3. With certain pigments that are not wetted well with kerosine, the substitution of turpentine has been found very efficient. However, when turpentine, or any other liquid having a high evaporation rate, is used, a pyknometer of type *a*

or *b*, Fig. 1, is not satisfactory, on account of losses around the ground-glass joints. When using such liquids as turpentine, the bottle (as a pyknometer) and apparatus as described in Section 13 under Method *C* should be used, except that instead of attempting to measure an accurate volume of the liquid from the burette, the bottle (plus the sample plus the wetting liquid) is finally weighed as in Method *B*.

The sub-committee also recommends that the Tentative Method of Test for Specific Gravity of Pigments (D 238 – 26 T)[1] be revised to read as given below, and that the method as revised be adopted as standard and added to the Standard Methods D 153 as Method *C*, For the Rapid and Accurate Testing of Single Samples, thereby placing all methods of test for the specific gravity of pigments under one serial designation:

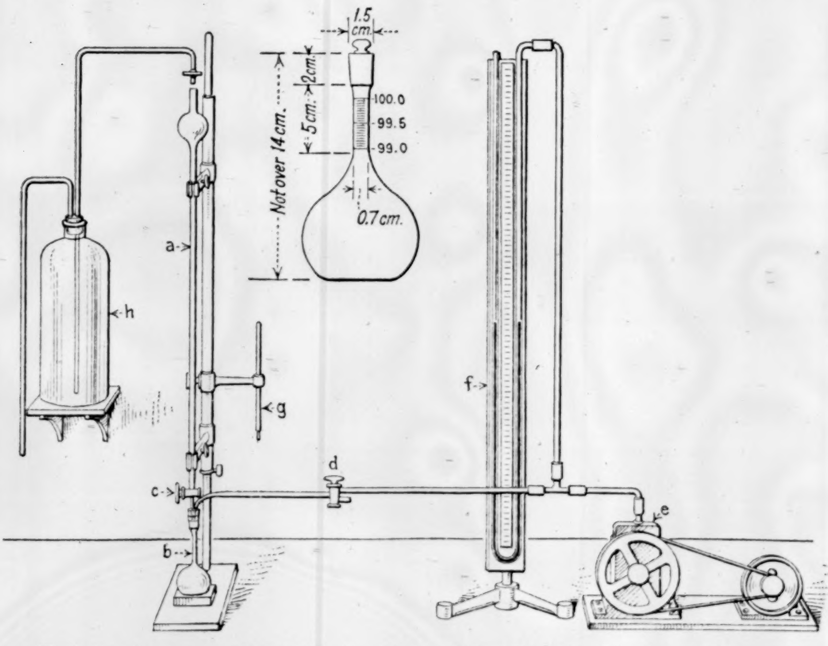

FIG. 3.—Apparatus Assembly for Determining Specific Gravity of Pigments.

METHOD *C*.[illegible]PID AND ACCURATE TESTING OF SINGLE SAMPLES

APPARATUS

13. *Apparatus*[illegible]e apparatus shall consist of the following (see Fig. 3):

(*a*) A 100-cc. b[illegible]tte with a 75-cc. bulb in the upper part and the lower part (25 cc.) graduated in 0.05 cc. (see Fig. 4).

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 26, Part I, p. 811 (1926); also 1926 Book of A.S.T.M. Tentative Standards, p. 362.

(*b*) A special 100-cc. graduated flask, *b*, Fig. 3, with ground-glass stopper. The flask shall be thick enough to withstand and maintain a vacuum and should weigh less than 35 g. The neck of the flask should be graduated in 0.05 cc. between the 99 and 100-cc. marks. The dimensions of the flask are shown in Fig. 3.

(*c*) A tightly-ground stop-cock *c*, in the burette *a*.

(*d*) A 3-way stop-cock *d*, connecting with the vacuum pump *e*.

(*e*) A high vacuum pump *e*, of the type requiring no preliminary or "backing" pump.

NOTE.—The "Hyvac" oil pump is satisfactory.

(*f*) An open-tube manometer *f*, Fig. 3, as described in Section 1 (*c*).

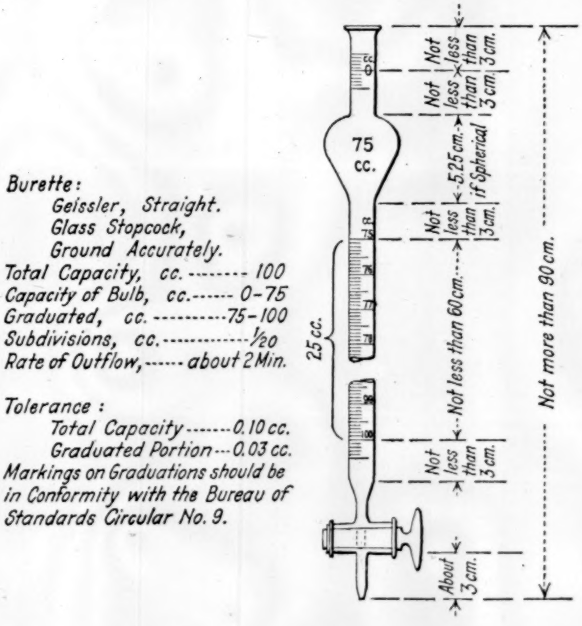
Burette:
Geissler, Straight.
Glass Stopcock,
Ground Accurately.
Total Capacity, cc. -------- 100
Capacity of Bulb, cc. ------ 0-75
Graduated, cc. ---------- 75-100
Subdivisions, cc. ------------ 1/20
Rate of Outflow, ------ about 2 Min.
Tolerance :
Total Capacity ------- 0.10 cc.
Graduated Portion --- 0.03 cc.
Markings on Graduations should be in Conformity with the Bureau of Standards Circular No. 9.
cc 0
75 cc.
75
76
77
78
99
100
25 cc.
Not less than 3 cm.
Not less than 3 cm.
5.25 cm. if Spherical
Not less than 3 cm.
Not less than 60 cm.
Not less than 3 cm.
About 3 cm.
Not more than 90 cm.

FIG. 4.—100-cc. Glass Burette.

NOTE.—The difference in levels of the mercury in the manometer when the system is in operation, subtracted from the barometer reading taken at the same time, gives the vacuum of the system in millimeters of mercury. The difference between the barometer and the manometer readings should not exceed 1 mm.

(*g*) A thermometer *g*, having a range of from 0 to 60° C. graduated in 0.1° C.

(*h*) A storage bottle *h*, for kerosine or other wetting liquid.

PROCEDURE

14. *Standardization of Apparatus.*—The flask shall be connected to the burette and pump by means of a two-hole rubber stopper. The system shall

be evacuated with stop-cock *c* closed until the pump maintains a vacuum of 1 mm. in the flask (this requires only a few minutes). Close the 3-way stop-cock *d* for 30 seconds, and again open to the pump. There should be no appreciable change in the mercury levels in the manometer, indicating that the system beyond stop-cock *d* is tight. With the vacuum still maintained, fill the burette from the top with kerosine, adjusting the level to the zero mark with a piece of capillary tubing. Now close stop-cock *d* and then carefully open stop-cock *c*, admitting about 75 cc. of kerosine into the flask. Open stop-cock *d* to the air, thus releasing the vacuum in the flask, and fill with kerosine to a definite mark on the neck of the flask. Read the burette, calling this reading K (the volume of the flask).

15. *Method.*—The flask shall then be cleaned with ether, dried, and weighed. A glass counterpoise having the same superficial area and treated the same way may be placed on the opposite pan in the balance. A quantity of the dry pigment to be tested shall be transferred to the flask by means of a clean, dry, glass funnel whose stem reaches to the bottom of the bulb. A piece of stiff nickel wire is convenient in pushing the powder down the stem. The bulb of the flask should be nearly filled with the sample which, however, should occupy a volume of less than 25 cc. after all air is expelled. Greater accuracy may be obtained with a large sample than with a small one. The inside stem as well as the entire outside of the flask should be wiped with a clean piece of dry, lintless cloth. The flask and pigment shall then be weighed and the weight of pigment computed by deducting the weight of the empty flask. With the burette clean and dry, but with the stop-cocks well lubricated (castor oil or glycerin), the flask shall be attached to the evacuating system as shown in Fig. 3. After closing stop-cocks *c* and *d*, the pump shall be started and stop-cock *d* carefully opened to the pump. Evacuation shall be continued until the pump maintains a vacuum of 1 mm. in the flask, or until all the air is expelled from the system. The burette shall then be filled from the top as described in Section 14, stop-cock *d* closed, stop-cock *c* gradually opened and kerosine added until the pigment is covered. The flask shall be tapped gently to dislodge any air bubbles. The pump should be stopped, stop-cock *d* opened to the air, and the flask filled up to the same mark as was obtained in determining its volume. The volume of kerosine required may be designated X. Note the height of the liquid in the burette to the nearest estimated 0.01 cc.

NOTE.—The removal of all air can not be stressed too greatly, as the presence of air will cause low results.

16. *Calculation.*—The specific gravity shall be calculated from the formula:

$$\text{Specific Gravity of Pigment} = \frac{S}{K-X}$$

where

S = weight of pigment used;
K = volume of kerosine required to fill the flask when empty;
X = volume of kerosine required to fill the flask when the pigment is present.

17. *Temperature.*—Since the specific gravity of a pigment is only slightly affected by temperature, such variations as occur under normal conditions in a room would not materially affect the results. Care shall be taken, however,

that the temperature of the liquid after transferring to the flask is approximately the same as it was when in the burette.

18. *Wetting Medium.*—While kerosine has been found to be a good wetting medium, any liquid which does not have a high evaporation rate may be used. The liquids are interchangeable, as no constants on them need be determined. Hence, a pigment containing a dye which is slightly soluble in kerosine could be run with another liquid in the same apparatus without special standardization for that liquid. Operators are cautioned against the use of water as it causes considerable frothing with certain pigments.

19. (*a*) *Precautions.*—Care shall be taken that the burette stop-cock is well ground in order to prevent leakage of kerosine. Castor oil is suggested as the stop-cock lubricant.

(*b*) Since in determining both K and X, the tip of the burette and bore of the stop-cock plug are empty, no correction is needed; stop-cock c, however, should be so well ground that under a vacuum of 1 mm. for 30 minutes no leakage of kerosine takes place. The usual sources of error are failure to remove all the air from the pigment and leaks in the system. The minimum amount of rubber tubing should be used anywhere in the system, and wherever this is used the joints between rubber and glass should be coated with a melted mixture of beeswax and rosin.

(*c*) In cleaning the flask of kerosine only, a rinsing two or three times with ether followed by dry air (dried over sulfuric acid and calcium chloride) is sufficient. When pigment is also present, both pigment and kerosine should be shaken together and then emptied. This should be followed with ether until no more pigment is removed. Some filter pulp (macerated filter paper) and water (with or without some glass beads) should be added and shaken vigorously. Repetition may be necessary. The flask should then be rinsed with distilled water and either dried in an oven or rinsed with alcohol and ether followed by dry air. In determining specific gravity by this method, there is no reason why the flask if made of Pyrex glass can not be heated, followed by cooling during evacuation if such heating has no effect on the sample.

The sub-committee recommends the following revisions in the standard methods as indicated below and that the methods, as revised, be continued as standard.

Standard Method of Routine Analysis of White Pigments (D 34-17).[1]—Change the "General Method" from its present form: namely,

"True specific gravity shall be determined by Thompson's[a] method, or by means of a 50-cc. pyknometer, using c. p. benzine and 10 to 20 g. of pigment."

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[a] *Proceedings*, Am. Soc. Test. Mats., Vol. XIII, p. 407 (1913).

to read as follows:

"True specific gravity shall be determined in accordance with the Standard Method of Test for Specific Gravity of Pigments (Serial Designation: D 153) of the American Society for Testing Materials."

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[1] **1924 Book of A.S.T.M. Standards.**

In the calculation under Mixed Calcium and Magnesium Carbonates, under Calcium Pigments, change the figure "1.7844" to read "1.784."

Standard Methods of Routine Analysis of Dry Red Lead (D 49 - 18).[1]—

Section 2.—Change from its present form: namely,

> "True specific gravity shall be determined by Thompson's method,[a] or by means of a 50-cc. pyknometer, using c. p. benzine and 20 g. of pigment."

---

[a] *Proceedings*, Am. Soc. Testing Mats., Vol. XIII, p. 407 (1913).

to read as follows:

> "True specific gravity shall be determined in accordance with the Standard Method of Test for Specific Gravity of Pigments (Serial Designation: D 153) of the American Society for Testing Materials."

Section 6.—In the second paragraph, entitled Calculation, change the figure "0.94193" to read "0.942"; and also change the figure "2.69973" to read "2.7."

Standard Methods of Routine Analysis of Yellow, Orange, Red, and Brown Pigments Containing Iron and Manganese (D 50 - 18).[1]—

Section 1.—Change from its present form: namely,

> "True specific gravity shall be determined by Thompson's method,[a] or by means of a 50-cc. pyknometer, using c. p. benzine and 10 to 20 g. of pigment."

---

[a] *Proceedings*, Am. Soc. Testing Mats., Vol. XIII, p. 407 (1913).

to read as follows:

> "True specific gravity shall be determined in accordance with the Standard Method of Test for Specific Gravity of Pigments (Serial Designation: D 153) of the American Society for Testing Materials."

Section 14.—In the last sentence of the third paragraph, change the figure "0.5969" to read "0.597."

Section 17.—In the second paragraph, entitled "Standard $KMnO_4$ Solution," change the figure "0.1968" to read "0.197"; and also change the figure "0.1639" to read "0.164."

Standard Methods of Routine Analysis of Yellow and Orange Pigments Containing Chromium Compounds, Blue Pigments and Chrome Green (D 126 - 23).[1]—

Section 1.—Change from its present form: namely,

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[1] 1924 Book of A.S.T.M. Standards.

"True specific gravity shall be determined by Thompson's method,[a] or by means of a 50-cc. pyknometer, using c. p. benzene, or by Gardner's method.[b]"

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[a] *Proceedings*, Am. Soc. Testing Mats., Vol. XIII, p. 407 (1913).

[b] Standard Method of Test for Specific Gravity of Pigments (Serial Designation: D 153) of the American Society for Testing Materials.

to read as follows:

> "True specific gravity shall be determined in accordance with the Standard Method of Test for Specific Gravity of Pigments (Serial Designation: D 153) of the American Society for Testing Materials."

Section 2.—Change the second sentence to read as follows by the addition of the italicized words and figures and the omission of those in brackets:

> "Weigh out accurately a portion of the color [(0.05 g. of yellow or green; 0.01 of blue)] (*0.02* g. *of yellow; 0.01 g. of green or blue*), place on a large glass plate, add [12] *24* drops of bleached linseed oil ([24] *36* drops with blues), [and rub up with a flat-bottomed glass pestle or muller;] *and mix with a clean steel spatula until the mass appears to be homogeneous;* add pure ZnO ([1] *2* g. for yellows or greens, [2] *3* g. for blues), and grind with a circular motion 50 times, *using a flat-bottomed glass pestle or muller;* gather up with a sharp-edged spatula and grind out twice more in like manner, giving the pestle a uniform pressure."

Section 6.—Change the first sentence from its present form: namely,

> "Nearly neutralize with NH_4OH the filtrate from the insoluble matter (or the original solution), dilute to about 300 cc., and pass into the clear solution a rapid current of H_2S until all of the lead is precipitated as PbS."

to read as follows:

> "Add NH_4OH to the filtrate from the insoluble matter (or the original solution) until a faint precipitate begins to form, then add 5 cc. of concentrated HCl (sp. gr. 1.19), dilute to 500 cc., and pass into the clear solution a rapid current of H_2S until all of the lead is precipitated as PbS."

At the end of this section, add a sentence to read as follows:

> "Save the alcoholic filtrate from the $PbSO_4$, evaporate nearly to dryness and add to the filtrate from the PbS."

Section 7.—Change the fifth sentence to read as follows by the addition of the italicized words and the omission of those in brackets:

> "If iron and aluminum are present, dissolve the NH_4OH precipitate with hot dilute HCl, washing the paper with hot water; [cool, add NH_4OH until alkaline, and then add Na_2O_2 (about 1 g.), keeping the beaker covered] *evaporate to about 100 cc., cool, add NH_4OH until alkaline, and then add Na_2O_2 (containing at least 90 per cent of Na_2O_2) in small portions to the cooled solution (10 to 12° C.) until oxidation is complete, keeping the beaker covered.*"

At the end of this section, add the following:

"or by the persulfate method,[a] as follows:

"For c. p. chrome yellows use an 0.25-g. sample, for c. p. chrome greens use an 0.5-g. sample, and for commercial chrome greens use a 1-g. sample. Weigh the sample, transfer to a 600-cc. Pyrex beaker, add 25 cc. of concentrated H_2SO_4, and fume lightly on a hot plate for 3 or 4 minutes. Excessive fuming or *cooking* over a hot flame is neither necessary nor desirable, as it may produce the difficultly soluble anhydrous chromium sulfate. The Prussian blue color is destroyed in a few minutes. Cool, cautiously dilute with water to 300 cc., stir, and heat to boiling. To the boiling solution add a small amount of permanganate (0.5 to 1 cc. of 0.1 *N* $KMnO_4$) to insure the presence of some manganese. Then add to the boiling solution 10 cc. of $AgNO_3$ solution (2.5 g. in enough water to make 1 liter) and 20 cc. (adding this slowly) of ammonium persulfate solution (4 g. of ammonium persulfate of full strength dissolved in 20 cc. of water). The hot solution should show the usual permanganate color. If this color does not develop, or if it disappears, add more persulfate. When the permanganate color is permanent, continue the boiling (best done on a hot plate) for 10 to 15 minutes to destroy excess persulfate. Then add 5 cc. of dilute HCl (1:3) and boil for 5 to 8 minutes to reduce the oxidized manganese. The color now should be the usual chromate yellow. Cool to about 20° C. and titrate either electrometrically with ferrous sulfate,[b] or add a measured excess of ferrous sulfate solution (beyond the deep grass-green color) and titrate back with 0.1 *N* permanganate. The first faint permanent darkening of the green color is taken as the end point.

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[a] E. F. Hickson, *Circular No. 294*, Scientific Section, Am. Paint and Varnish Manufacturers. Assn., November, 1926.

[b] Kelley, *Journal of Industrial and Engineering Chemistry*, Vol. 13, p. 1053 (1921).

"Correction for a blank (about 0.2 cc. of $KMnO_4$) due to color, etc., should be made.

NOTES

"In commercial chrome greens containing silicates and barium sulfate, filtration to remove the "acid insoluble matter" after fuming the sample with acid and diluting is advisable though not necessary. The end point of the subsequent titration of the clear solution is easier to see, and there is less chance for "bumping" during boiling if these are removed.

"In the case of c. p. greens and yellows, the solution, after fuming with sulfuric acid and diluting, could be filtered and the precipitated lead sulfate weighed directly for total lead. This would likewise give a clear filtrate for the chromium titration.

"The important precautions are to avoid overheating with sulfuric acid, and to make sure that the persulfate (solid material) has not deteriorated. It should contain over 90 per cent of the reagent."

Section 11.—Change from its present form: namely,

"Weigh 5 g. of the pigment on to a weighed Gooch crucible (containing asbestos, and dried at 110° C.), wash six times with 25-cc. portions of cold water; dry at 110° C. and weigh. The loss in weight, corrected for moisture (as determined above), represents the soluble salts removed by the water. The washings may be examined, if desired."

to read as follows:

"Weigh 2.5 g. of the pigment and transfer to a graduated 250-cc. flask, add 100 cc. of water, and boil for 5 minutes. Dilute with water, let stand until at room temperature, make up to the mark with water, mix, and let settle. Filter through dry paper and discard the first 25 cc. Transfer 100 cc. of the clear filtrate to a weighed dish, evaporate to dryness on a steam-bath, dry in an oven at 105 to 110° C. to constant weight (30 minutes will usually suffice); cool and weigh."

Section 12.—Change the heading from its present form: namely, "Added Coloring Matter and Tinting Strength" to read as follows, "Tinting Strength and Added Coloring Matter."

Change the reference to Section 3 to a reference to Sections 2 and 3.

Section 23.—Change the heading from its present form: namely, "Added Coloring Matter and Tinting Strength" to read as follows, "Tinting Strength and Added Coloring Matter."

Change the reference to Section 3 to a reference to Sections 2 and 3.

Section 54.—Change the heading from its present form: namely, "Added Coloring Matter and Tinting Strength" to read as follows, "Tinting Strength and Added Coloring Matter."

Change the reference to Section 3 to a reference to Sections 2 and 3.

Standard Methods of Routine Analysis of Titanium Pigments (D 186 - 25).[1]—

Section 1.—Change from its present form: namely,

"True specific gravity shall be determined by Gardner's method.[a]"

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[a] Standard Method of Test for Specific Gravity of Pigments (Serial Designation: D 153) of the American Society for Testing Materials, 1924 Book of A.S.T.M. Standards.

to read as follows:

"True specific gravity shall be determined in accordance with the Standard Methods of Test for Specific Gravity of Pigments (Serial Designation: D 153) of the American Society for Testing Materials."

Section 4.—Change from its present form: namely,

"Dry in an oven at 105 to 110° C., a No. 325 sieve, cool, and weigh accurately. Weigh 10 g. of the sample, wash with water through the sieve, breaking up all lumps either by gentle pressure with a pestle in a mortar, but not grinding, or with a brush on the sieve. After washing with water until all but the particles too coarse to pass the sieve have been washed through, dry the sieve for one hour at 105 to 110° C., cool, and weigh.

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[1] A.S.T.M. Standards Adopted in 1925.

to read as follows:

"Determine coarse particles in accordance with the Standard Methods of Test for Coarse Particles in Paint Pigments (Serial Designation: D 185) of the American Society for Testing Materials.

Section 8.—In the paragraph designated (4) change the figure "0.00481" to read "0.0048" and the figure "0.00801" to read "0.008."

Section 12.—In the first sentence, change the figure "3.161" to read "3.2." Change the next to the last sentence of the first paragraph to read as follows by the addition of the italicized figures and the omission of the figures and words in brackets:

"The weight of sodium oxalate used multiplied by [0.8334] *0.833* gives its iron equivalent, or multiplied by [1.1954] *1.195* gives its titanium dioxide equivalent [(International Atomic Weights, 1921–1922)].

Standard Method of Test for Coarse Particles in Paint Pigments (D 185 - 26).[1]—

Section 1.—Omit the footnote to this section, reading as follows:

"Sieves 3 in. in diameter will be received by the U. S. Bureau of Standards for test. The cloth will be tested to determine whether or not it conforms to the specifications for cloth of the U. S. Bureau of Standard Sieve Series. The specifications for the sieve frame are now geing prepared. No. 325 (44 micron) cloth of the U. S. Standard Sieve Series should be made of wire 0.036 mm. (0.0014 in.) in diameter, a tolerance of 15 per cent under and 35 per cent over being allowed on this diameter. The average opening between adjacent parallel wires should be 0.044 mm. (0.0017 in.), the tolerance being 8 per cent with the additional limitation that the maximum opening shall not exceed 0.044 mm. by more than 90 per cent. Sieves whose cloth conforms to these specifications and whose frames are in accordance with specifications now in preparation will be marked with the letters "BS" and the year in which the test is made. A report will be issued for each sieve submitted, a nominal fee being charged for this test."

Change the first sentence of this section to read as follows by the addition of the italicized words:

"The apparatus shall consist of a 3-in. No. 325 (44 micron) sieve *conforming to the requirements of the Standard Specifications for Sieves for Testing Purposes (Serial Designation: E 11) of the American Society for Testing Materials.*"

Tentative Methods of Routine Analysis of White Linseed Oil Paints (D 215 - 25 T).[2]—

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[1] A.S.T.M. Standards Adopted in 1926.

[2] *Proceedings,* Am. Soc. Testing Mats., Vol. 25, Part I, p. 664 (1925); also 1926 Book of A.S.T.M. Tentative Standards, p. 367.

It is recommended that the following revisions be made in these methods, and that the methods as revised be continued as tentative:

Omit the section on "Hanus Solution" reading as follows:

"Dissolve 13.2 g. of iodine in 1000 cc. of 99.5-per-cent glacial acetic acid which will not reduce chromic acid. Add enough bromine to double the halogen content as determined by titration (3 cc. of bromine is about the proper amount). The iodine may be dissolved by the aid of heat, but the solution should be cold when the bromine is added."

Substitute therefor a section to read as follows:

"*Wijs Solution.*—Dissolve iodine in glacial acetic acid that has a melting point of 14.7 to 15° C. and is free from reducing impurities in the proportion so that 13 g. of iodine will be present in 1000 cc. of solution. The preparation of the iodine monochloride solution presents no great difficulty but it shall be done with care and accuracy in order to obtain satisfactory results. There shall be in the solution no sensible excess either of iodine or more particularly of chlorine over that required to form the monochloride. This condition is most satisfactorily attained by dissolving in the whole of the acetic acid to be used the requisite quantity of iodine, using a gentle heat to assist the solution, if it is found necessary. Set aside a small portion of this solution while pure, and pass dry chlorine into the remainder until the halogen content of the solution is doubled. Ordinarily, it will be found that by passing the chlorine into the main part of the solution until the characteristic color of free iodine has just been discharged, there will be a slight excess of chlorine which is corrected by the addition of the requisite amount of the unchlorinated portion until all free chlorine has been destroyed. A slight excess of iodine does little or no harm, but excess of chlorine must be avoided."

Under "Potassium Permanganate Solution" change the amount of sodium oxalate to be dissolved from "0.40 to 0.50 g." to read "0.25 to 0.30 g. (accurately weighed)."

Change the figure "0.8334" in this section to read "0.833."

In Paragraph (*c*) on iodine number of fatty acids under Testing Non-Volatile Vehicle, change the seventh, eighth and ninth sentences to read as follows by the addition of the italicized words and the omission of those in brackets:

"Whirl the bottle *or flask* to dissolve the sample. Add 10 cc. of chloroform to two empty bottles *or flasks* like that used for the sample. Add to each bottle *or flask* 25 cc. of the [Hanus] *Wijs* solution (see 'Reagents') and let stand with occasional shaking for [30 minutes] *1 hour in a dark place at a temperature of from 21 to 23° C.*"

At the end of this section add a new Paragraph (*d*) to read as follows:

"(*d*) *Rosin.*

Liebermann-Storch Test.[a]—To about 1 g. of the fatty acids add 15 cc. of acetic anhydride and shake until solution is complete. Pour a few drops of this solution on a white porcelain plate (a crucible cover serves well) and add a drop of H_2SO_4 (sp. gr. 1.53). A fugitive violet color indicates rosin.

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[a] "Chemical Technology and Analysis of Oils, Fats and Waxes," by J. Lewkowitsch, Vol. 1, p. 623 (1921).

Halphen-Hicks Test.[b]—Place about 1 g. of the fatty acids in a cavity of an ordinary porcelain color-reaction plate. Fill the cavity with a solution of one part by volume of phenol dissolved in two parts by volume of carbon tetrachloride. Stir the mixture. Fill another cavity of the porcelain plate with a solution of one part by volume of bromine and four parts by volume of carbon tetrachloride. Cover the whole plate with an inverted watch glass. If rosin is present the bromine fumes develop very soon an indigo blue color which persists for some time."

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[b] *Journal of Industrial and Engineering Chemistry*, Vol. 3, p. 86 (1911).

In the second paragraph under Antimony Oxide omit the sixth, seventh, eighth and ninth sentences reading as follows:

"For special work, after digesting, dilute to 100 cc. with water, add 1 to 2 g. of Na_2SO_3, and boil until all the SO_2 is expelled. This is shown when no blue color is obtained with starch-iodate paper (see 'Reagents'); the volume will be reduced about one-half. Dilute to 250 cc. with water, add 20 cc. of HCl (sp. gr. 1.19), and complete the determination as described. Calculate total Sb to Sb_2O_3.

Substitute a note to read as follows:

"NOTE.—If the digestion with H_2SO_4 and K_2SO_4 (plus filter paper) is continued after the solution becomes colorless, some of the antimony may be oxidized from the *ous* to the *ic* condition. In such cases, cool, wash off the funnel, dilute to 100 cc. with water, add 1 to 2 g. of Na_2SO_3 and boil until all of the SO_2 is expelled. This is shown when no blue color is obtained with starch-iodate paper (see 'Reagents'); the volume will be reduced about one-half. Dilute to 250 cc. with water, add 20 cc. of HCl (sp. gr. 1.19), and boil 2 minutes; cool to 10 to 15° C., and titrate to a faint pink tint with 0.1 *N* $KMnO_4$ solution. Calculate total Sb to Sb_2O_3. Subtract the Sb_2O_3 found by the procedure given in the preceding paragraph from the total Sb_2O_3 and calculate the residual Sb_2O_3 to Sb_2O_5."

Under "Antimony Oxide (in the presence of appreciable amounts of iron)" change the fifth, sixth, seventh and eighth sentences to read as follows by the addition of the italicized word and the omission of those in brackets:

"Cool, wash off the funnel, [carefully dilute the solution to 100 cc. with water, add about 1 g. of Na_2SO_3, and boil until all of the SO_2 is expelled. (Solution will be reduced to less than one-half its former volume). This is shown when no blue color is obtained with starch-iodate paper (see 'Reagents'). Dilute] *dilute* to about 250 cc. with water, add 20 cc. of HCl (sp. gr. 1.19), boil for 2 or 3 minutes, cool to about 10° C., and titrate to a faint pink tint with 0.1 *N* $KMnO_4$ solution (see 'Reagents')."

At the end of the paragraph add a note to read as follows:

"NOTE.—If the digestion with H_2SO_4 and K_2SO_4 (plus filter paper) is continued after the solution becomes colorless, some of the antimony may be oxidized from the *ous* to the *ic* condition. In such cases, cool, wash off the funnel, dilute to 100 cc. with water, add 1 to 2 g. of Na_2SO_3 and boil until all of the SO_2 is expelled. This is shown when no blue color is obtained with starch-iodate paper (see 'Reagents'); the volume will be reduced about one-half. Dilute to 250 cc. with water, add 20 cc. of HCl (sp. gr. 1.19), and boil 2 minutes; cool to 10 to 15° C., and titrate to a faint pink tint with 0.1 *N* $KMnO_4$ solution."

Change Note 2 from its present form: namely,

"In the absence of much gum or resin the iodine number gives the best, though doubtful, indication of linseed oil. The fatty acids may be tested for rosin and examined for unsaponifiable matter, following the methods given in the books on paints analysis. In some cases it may be desirable to let a portion of the well-mixed paint stand until the pigment settles out (or settle by means of a centrifuge), decant the vehicle, distil off the thinner, and examine the non-volatile vehicle."

to read as follows:

"If appreciable amounts of resin or of unsaponifiable matter are found to be absent in the vehicle of a paint, the iodine number of the fatty acids gives the best indication (though not proof) of the presence of linseed oil. An iodine number of less than 175 (Wijs) for the fatty acids is an indication that the non-volatile vehicle was not pure linseed oil."

Respectfully submitted on behalf of the sub-committee,

F. W. SMITHER,
Chairman.

REPORT OF SUB-COMMITTEE XIII ON SHELLAC

The sub-committee recommends that the Tentative Specifications for Orange Shellac (D 237 – 26 T)[1] be advanced to standard.

The sub-committee has found that there are certain commercial orange shellacs and garnet lacs on the market (known as "machine-made") in which the nature of the wax has been so altered through a special method of manufacture that the present standard method for determination of wax in shellac is not applicable. A new Tentative Method of Test for Determination of Wax in Shellac ("Machine-Made" and Dry-Bleached Refined Shellac) appended hereto[2] is proposed to be added when adopted to the present Standard Method for Determination of Wax in Shellac (D 29 – 25).[3]

The sub-committee, during the past year, has made a study of the determination of matter insoluble in hot alcohol, with special reference to its application to dry bleached shellac. It has been found that it may be advisable in this connection to describe in more detail the exact conditions under which the above test shall be carried out. The sub-committee feels, however, that more cooperative work should be carried out before recommending a definite revision of the method or in the wording as described in Standard Methods D 29 – 24.

As a result of the sub-committee's experience, and to safeguard the method for the present, the following modification of the Method for Determination of Matter Insoluble in Hot-Alcohol is offered for discussion, but without recommendation at this time:

> The alcohol and shellac mixture should be brought to a brisk boil and maintained for 30 minutes at or near the boiling point. Extract for one hour and to constant weight.
>
> An 8-in. glass condenser may be substituted for the metal condenser now in use, the stem perforated with 2 holes, from which the syphon is suspended by wire. The condenser is fitted to the neck of the flask (same size and type as described for the method) with a cork stopper. A free flow of cooling water should be maintained during extractions. The use of an Allihn condenser for extractions (with bulbs) is recommended.
>
> NOTE.—The above recommendation is made to insure extraction at the boiling point of alcohol.

The sub-committee recommends that the Appendix to the Tentative Methods of Testing Shellac Varnish (D 214 – 26 T)[1] be revised as indicated below and that the tentative methods as revised be continued as tentative:

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 26, Part I, p. 796 (1926); also 1926 Book of A.S.T.M. Tentative Standards, p. 345.

[2] See p. 869.—ED.

[3] A.S.T.M. Standards Adopted in 1925.

Change the references to temperature from "16° C. (60° F)" to 15.5° C. (60° F.)

Change the values of weights per gallon of varnish from their present form to agree with the following values:

TAKING WEIGHT OF WATER 1 GAL. = 8.33 LB.

WHITE SHELLAC, LB. PER GAL. OF ALCOHOL	WEIGHT PER GAL. OF VARNISH, LB.
3	7.544
3.5	7.636
4	7.729
4.5	7.809
5	7.884
5.5	7.938
6	7.994

TAKING WEIGHT OF WATER 1 GAL. = 8.33 LB.

ORANGE SHELLAC, LB. PER GAL. OF ALCOHOL	WEIGHT PER GAL. OF VARNIGH, LB.
3	7.497
3.5	7.592
4	7.687
4.5	7.762
5	7.826
5.5	7.914
6	7.958

Add two notes to read as follows:

NOTE.—The above figures are the most important in the tables to the varnish industry as considerable shellac varnish is now sold by weight, or the gallonage is determined by dividing the net weight by its corresponding factor.

NOTE.—Hydrometers should not be employed to determine the specific gravity or degrees Baumé of a shellac varnish, as readings so obtained are unreliable and inaccurate. The specific gravity of a shellac varnish can be accurately determined either with a specific gravity bottle (pyknometer) or by weighing accurately 100 cc. of the varnish at 60° F. in a 100-cc. graduated flask, which has been calibrated with distilled water at the same temperature.

The program of work set up for this sub-committee at the beginning of the season anticipated the completion of experimental and corroborative work on the method of test for insoluble matter in shellac. However, this was not accomplished due to the fact that at the beginning of the year the work was suspended when the question was brought up as to whether the combined shellac interests would be willing to appropriate a sum of money to employ a chemist to assist in this work. It was the thought that this chemist would probably reside in Washington and would thus be in a position to thoroughly investigate the present methods of test for shellac and, possibly, work out improvements in these with the assistance and advice of the Bureau of Standards experts.

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 26, Part I, p. 804 (1926); also 1926 Book of A.S.T.M. Tentative Standards, p. 355.

The sub-committee has developed important and valuable methods of test, but as the members are all busy with their own special interests, the committee work has to wait on such time as they can give. It naturally would expedite matters if one man could devote all his time to these problems.

Respectfully submitted on behalf of the sub-committee,

J. W. PAISLEY,
Chairman.

REPORT OF SUB-COMMITTEE XV ON SPECIFICATIONS FOR PIGMENTS DRY AND IN OIL WHEN MARKETED IN THAT FORM

REVISIONS OF PRESENT STANDARD SPECIFICATIONS

The sub-committee has reviewed the present standard specifications for pigments and recommends a number of revisions in the Standard Specifications for Ocher (D 85 – 24)[1] in order to bring them in line with the best commercial practice. Requirements for ocher ground in japan have also been added. As the revisions in the specifications are numerous, they have been completely rewritten and are appended hereto in their proposed revised form.[2] The sub-committee recommends that the revised specifications be submitted to the Society for adoption immediately to replace the present standard specifications.

REVISIONS AND ADVANCEMENT TO STANDARD OF TENTATIVE SPECIFICATIONS

The sub-committee has given thorough study and discussion to the specifications for pigments, which have been on record as tentative for one or more years. These have been revised, mostly in minor details, in order to bring the specifications into closer conformity with the best commercial practice, and to clarify the phraseology where necessary.

These specifications are the following:

Tentative Specifications for Iron Oxide and Iron Hydroxide (D 84 – 25 T);[3]
Tentative Specifications for Chrome Yellow (D 211 – 26 T);[4]
Tentative Specifications for Pure Chrome Green (D 212 – 26 T);[4]
Tentative Specifications for Reduced Chrome Green (D 213 – 26 T).[4]

In the Tentative Specifications for Iron Oxide and Iron Hydroxide (D 84 – 25 T) the following revisions are recommended:

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[1] 1924 Book of A.S.T.M. Standards.

[2] See 1927 Book of A.S.T.M. Standards, Part II, p. 255.

[3] *Proceedings*, Am. Soc. Testing Mats., Vol. 25, Part I, p. 646 (1925); also 1926 Book of A.S.T.M. Tentative Standards, p. 347.

[4] *Proceedings*, Am. Soc. Testing Mats., Vol. 26, Part I, pp. 798–803 (1926); also 1926 Book of A.S.T.M. Tentative Standards, pp 349–354.

Title.—Change to read as follows by the addition of the italicized word and the omission of those in brackets:

> "Tentative Specifications for *Mineral* Iron Oxide [and Iron Hydroxide]."

Section 1.—Change to read as follows by the addition of the italicized words:

> "These specifications cover iron oxide and iron hydroxide pigments *of mineral origin and* of red and brown colors."

Section 3.—Add a new Paragraph (*a*) to read as follows, relettering the subsequent paragraphs accordingly:

> "The mass color and character of the tint formed by mixture with a white pigment shall be the same as, and the strength not less than, that of a sample mutually agreed upon by buyer and seller."

In the other three specifications, namely, for Chrome Yellow (D 211 - 26 T), for Pure Chrome Green (D 212 - 26 T) and for Reduced Chrome Green (D 213 - 26 T), the following revisions are recommended:

Section 3.—Change Paragraph (*a*) from its present form: namely,

> "The color and tone shall be equal to, and the tinting strength not less than, that of a sample mutually agreed on by buyer and seller."

to read as follows:

> "The mass color and character of the tint formed by mixture with a white pigment shall be the same as, and the strength not less than, that of a sample mutually agreed upon by buyer and seller."

Change the first sentence of Paragraph (*d*) to read as follows by the addition of the italicized words:

> "The pastes as received shall not be caked in the container and shall break up readily in turpentine to form a smooth paint of brushing consistency that will dry within one hour to a hard flat coat *that can be varnished within 5 hours of the time of application without streaking or bleeding.*"

The sub-committee recommends that these four specifications, as revised, be submitted to the Society for adoption as standard.

PROPOSED NEW TENTATIVE SPECIFICATIONS

The sub-committee has also formulated specifications for a number of additional pigments covering the following:

Prussian Blue,
Ultramarine Blue,
Chrome Oxide Green,
Commercial Para Red,
Titanium Barium Pigment,
Aluminum Powder for Paints,
Gold Bronze Powder.

It is recommended that these specifications be accepted for publication as tentative as appended hereto[1] so that they may be before the Society in definite form and be the subject of critical study and comment by those interested.

With the preparation of these new specifications there remain few, if any, pigments which are so extensively used as to be reasonable subjects for A.S.T.M. specifications. The revisions now proposed extend the specifications for certain of the pigments to include paste in japan as well as paste in oil. Further development may indicate still other forms or applications of some of the pigments which may require attention in specifications.

The sub-committee expects to continue the study of the proposed new tentative specifications, hoping that one or two years' general experience will indicate that in their present or in slightly revised form, they will be suitable for advancement to standard.

In a letter ballot of the sub-committee, consisting of 11 members, all have voted favorably on each of the individual items above reported, except one member from whom no reply was received.

Respectfully submitted on behalf of the sub-committee,

H. E. SMITH,
Chairman.

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[1] See pp. 850–861.—ED.

REPORT OF SUB-COMMITTEE XXIII ON ANTI-FOULING PAINTS

1925 SERIES OF TESTS

Object of Tests:

In the results of the 1924 series of tests, reported by the committee in 1925,[1] which was exclusively a test on vehicles, and in the results previously reported, the importance of the factor of fineness of particles as affecting solubility and rate of solution in sea water had been stressed by the members. It was decided, therefore, to make a series of tests with the varieties of copper oxide and mercury oxide very finely ground. The vehicle of the anti-fouling coat was to be that containing the best domestic synthetic resin of the 1924 series. In addition, there was inserted a paint containing this resin in both coats, in order to couple up the 1925 series with that of 1924.

The tests were all carried out on war vessels, through the courtesy of the U. S. Navy, which also conducted one panel test upon these five paints.

Spreading Power of the Paints.—The spreading power of the paints used, as reported by the Norfolk Navy Yard, was as follows:

ANTI-CORROSIVE PAINTS	SPREADING POWER, SQ. FT. PER. GAL.	ANTI-FOULING PAINTS	SPREADING POWER, SQ. FT. PER GAL.	ANTI-FOULING PAINTS	SPREADING POWER, SQ. FT. PER GAL.
Nos. 1, 2, 3 and 4	309	No. 1	240	No. 4	312
No. 5	168	No. 2	264	No. 5	296
No. 14R	324	No. 3	192	No. 15R	226

Composition of the Navy Paints.—The composition of the Navy Paints may be obtained in detail from the Navy. Paints 14R and 15R have a coal-tar rosin vehicle. Nos. 14A and 15A have a shellac-Yacca gum; likewise, wood rosin was a substitute. Alcohol is the solvent for the gums; with some pine oil. Zinc oxide and Indian red are the fillers for the anti-fouling, with oxide of mercury for the toxic. Zinc dust and zinc oxide are the pigments for the anti-corrosive.

Composition of the Paints, 1925 Series:

First Coat:

ANTI-CORROSIVE FOR PAINTS NOS. 1 AND 4, INCLUSIVE:

Pigment		66 per cent:
Aluminum stearate	1 per cent	
China clay	7 "	
Iron oxide	75 "	
Red lead	17 "	

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 25, Part I, p. 244 (1925).

Vehicle (general formula)		34 per cent:
Linseed oil	12.1 per cent	
Volatile materials	72.3 “	
Gums and resinates	15.6 “	
Same Vehicle (as actually used)		34 per cent:
Rubbing varnish	20.0 per cent	
Grinding japan	33.0 “	
Mineral spirits	6.8 “	
Benzol	9.2 “	
Pale gloss oil	9.8 “	
Light naphtha	21.2 “	

ANTI-CORROSIVE FOR PAINT No. 5:

Zinc dust	3 per cent
Zinc oxide	17 “
Spanish red oxide	10 “
Asbestine	34.9 “
Alcohol, S. D. No. 1	11.9 “
Syntellac “R”	6.8 “
Pine Tar Oil	6.4 “

Second Coat (Anti-fouling Coat):

VEHICLE FOR ANTI-FOULING COAT:

(To form of the total paint, 60 per cent)

Alcohol, S. D. No. 1	58.2 per cent
Syntellac “R”	19.7 “
Pine Tar Oil	11.4 “
Turpentine	10.7 “

PIGMENTS FOR ANTI-FOULING COAT:

The solids used below were ground so that not more than 2 per cent were retained on a No. 325 screen.

Base Pigment for Anti-fouling Coat:

(To bring total of pigment and toxic up to a total of 40 per cent of the whole paint.)

Zinc oxide	24.3 per cent
Spanish red oxide	57.1 “
Asbestine	18.6 “

Toxic Pigments of Anti-fouling Coat (325 mesh):

Ounces per gallon of whole paint

(Probable per cent in whole paint is also given)

		PAINT No. 1	PAINT No. 2	PAINT No. 3	PAINT No. 4	PAINT No. 5
Copper Oxide, scale	ounces	25	25	..	..	..
	per cent	15	15	..	..	..
Copper Oxide, electrolytic	ounces	..	..	25	25	25
	per cent	..	..	15	15	15
Mercuric Oxide, Red	ounces	1.5	..	1.5	..	..
	per cent	1	..	1	..	..
Mercuric Oxide, Yellow	ounces	..	1.5	..	1.5	1.5
	per cent	..	1	..	1	1

Results on Patches on Naval Vessels and Panel Tests, 1925 Series:

In the results given below, 10 represents the best grade.

	U. S. S. NEW YORK	U. S. S. KITTERY	U. S. S. JOHN D. EDWARDS	U. S. S. HENDERSON	U. S. S. TRACY	AVERAGE FOR SHIP TESTS	PANEL TESTS
Submerged	Sept. 28, 1925	Sept. 15, 1925	Sept. 25, 1925	Oct. 7, 1925	Mar. 31, 1926	......	Aug. 3, 1926
Inspected	Nov. 9, 1926	Feb. 1, 1926	Dec. 29, 1925	May 27, 1926	Jan. 21, 1927	.....	Dec. 9, 1926
Interval, days	407	138	95	232	297	......	127
CORROSION GRADES:							
Paint No. 1	...	8.5	5	4.5	6.8	6.2	7.8
Paint No. 2	...	7.5	5	5.3	6.4	6.1	8
Paint No. 3	...	8	3	7.5	6.2	6.2	6.5
Paint No. 4	...	8	4	7.5	6.6	6.5	7.5
Paint No. 5	...	5.5	4	6.6	6.6	5.7	2
Paint 14R-15R	...	9	7	...	6.8	7.6	...
Paint 14A-15A	...	7.3	6	6.5	7.6	7.0	...
Paint 14R-15A	...	...	...	...	7.8	7.8	...
Dark Metlac	...	...	8	...	...	8	...
Light Metlac	...	...	5	...	...	5	...
Wood rosin	...	...	2	...	...	2	...
Paint 14R-1273	5.3	5.3	5.3	5.0	7.8	7.8	...
FOULING GRADES:							
Paint No. 1	8.3	8.5	9	8	8.2	8.4	8
Paint No. 2	5.5	8.5	9	7.9	8.3	7.8	9
Paint No. 3	4.5	9	9	7.9	7.5	7.2	8.5
Paint No. 4	4.8	7.5	9	8.8	7.2	7.5	8.5
Paint No. 5	5.0	9.5	9	8.5	7.5	7.9	9
Paint 14R-15R	...	9.5	9	...	7.1	8.5	...
Paint 14A-15A	...	7	7.5	6	7.7	7.1	...
Dark Metlac	...	...	0	...	...	0	...
Light Metlac	...	...	9	...	...	9	...
Wood rosin	...	...	9	...	...	9	...
Paint 14R-15A	7.6	...	...	...	7.1	7.4	...
Paint 14R-1273	...	...	...	...	8.2	8.2	...
FILM GRADES:							
Paint No. 1	...	...	...	...	4.2	...	7.5
Paint No. 2	...	...	...	...	7.4	...	8.5
Paint No. 3	...	...	...	...	6.6	...	7
Paint No. 4	...	...	...	...	7.4	...	7
Paint No. 5	...	...	...	...	7.2	...	...
Paint 14A-15A	...	...	...	...	7.3	...	...
Paint 14R-1273	...	...	...	...	6.6	...	...
Paint 14R-15A	...	...	...	...	6.6	...	...
Paint 14R-15R	...	...	...	...	7.2	...	...

Further details may be obtained from the sub-committee.

Order of Resistance to Fouling:

The paints on all Ship Tests, beginning with the best, showed the following order of resistance:

PAINT	COMPOSITION
No. 1	Scale copper oxide and red mercury oxide.
No. 5	Electrolytic copper oxide, yellow mercury oxide, and syntellac in both coats.
No. 2	Scale copper oxide and yellow mercury oxide.
No. 4	Electrolytic copper oxide and yellow mercury oxide.
No. 3	Electrolytic copper oxide and red mercury oxide.

The table will in addition show the excellence of the Navy paints tried out at the same time, though none of them was included in all the tests.

One ship has not yet been inspected. One additional ship was inspected but the slime on the bottom prevented grading of the patches.

Discussion as to Fouling.—In making any comparisons, Paints Nos. 1, 2, 3, and 4 and 5 must be contrasted, because the first had all the same vehicles, and second had all the same pigments.

The conclusion is reached that scale copper oxide (containing both cuprous and cupric oxide) is about as satisfactory as the electrolytic or cuprous oxide, when both are ground to a very fine mesh. The same is true of the two varieties of mercury.

1926 SERIES OF TESTS

Object of the Tests:

The committee decided to attempt to settle the question of the comparative value of cuprous and cupric oxides as toxics and of other chemical compounds present in the common toxics in use by manufacturers by securing these compounds in as pure a form as available, with special analysis, grinding the samples to pass a No. 325 sieve, and placing them in a series of paints all with the same vehicle and with the same percentage of actual copper and mercury, respectively, the tests being confined to the compounds of these two metals.

Composition of the Paints, 1926 Series:

Paint No. 1.—

Cupric oxide, c. p., General Chemical Co. (78.68 per cent copper)	12.4 per cent
Filler	27.6 "
Vehicle	60 "

Paint No. 2.—

Cuprous oxide, c. p., General Chemical Co. (85.63 per cent copper)	11.4	per cent
Filler	28.6	"
Vehicle	60	"

Paint No. 3.—

Paris Green, Sherwin-Williams (24.7 per cent copper)	39.5	per cent
Filler	0.5	"
Vehicle	60	"

Paint No. 4.—

Copper Carbonate, c. p., General Chemical Co. (55.93 per cent copper)	17.5	per cent
Filler	22.5	"
Vehicle	60	"

Paint No. 5.—

Copper Cyanide, c. p., R. and H. Chemical Co. (70.49 per cent copper)	13.9	per cent
Filler	26.1	"
Vehicle	60	"

Paint No. 6.—

Copper Oleate, Shepherd (10.8 per cent copper)	33	per cent
Cuprous oxide	7	"
Vehicle	60	"

Paint No. 7.—

Copper Resinate, Shepherd (8.5 per cent copper)	31.8	per cent
Cuprous oxide	8.2	"
Vehicle	60	"

Paint No. 8.—

Yellow Mercuric Oxide, c. p., Mallinckrodt (99.7 per cent copper)	5.3	per cent
Filler	34.7	"
Vehicle	60	"

Paint No. 9.—

Red Mercuric oxide, c. p., Mallinckrodt (99.5 per cent copper)	Same as No. 8 for all

Paint Nos. 10 to 16.—

Mixtures by equal weights of No. 8 with Nos. 1, 2, 3, 4, 5, 6, 7, respectively.

Paint No. 17.—

Mixtures of equal weight of No. 9 and No. 2.

The vehicle shall be the same in all, to form 60 per cent of whole paint, as follows:

Crude mineral oil	5.85	per cent
Pale gloss oil	81.41	"
Solvent naphtha	6.46	"
Grinding japan	6.28	"

The filler was:

Zinc oxide	24.3	per cent
Spanish red oxide	57.1	"
Asbestine	18.6	"

Results with Panel Tests, 1926 Series:

	HAMPTON ROADS, VA.	RARITAN BAY, N. J.	BEAUFORT, N. C.	AVERAGE	BEAUFORT, N. C.
Submerged	Aug. 3, 1926	June 14, 1926	May 18, 1926	....	May 18, 1926
Inspected	Dec. 9, 1926	Nov. 15, 1926	July 28, 1926	....	Nov. 15, 1926
Interval, days	127	154	71		181
CORROSION GRADES:					
Paint No. 1	7.3	5	3	5.1	..
Paint No. 2	8	7	10	8.3	6
Paint No. 3	6.2	4	2	4.1	2
Paint No. 4	8.5	9	3	6.8	..
Paint No. 5	4.5	6.5	7	6	6
Paint No. 6	8	5.5	0	4.5	..
Paint No. 7	7	4	2	4.3	4
Paint No. 8	7.8	10	10	9.3	6
Paint No. 9	8.3	8.5	10	8.9	6
Paint No. 10	5.8	8.5	6	6.8	6
Paint No. 11	9	7.5	10	8.8	6
Paint No. 12	7.5	5	5	5.8	8
Paint No. 13	8.5	7	5	6.8	8
Paint No. 14	5.9	5	7	6	8
Paint No. 15	8	4	6	6	8
Paint No. 16	8.5	7	5	6.8	4
Paint No. 17	7.3	8.5	9	8.3	6
FOULING GRADES:					
Paint No. 1	4.5	7	3	4.8	..
Paint No. 2	8.8	9	10	9.3	0
Paint No. 3	7	9	2	6	0
Paint No. 4	7.8	9.5	3	6.8	..
Paint No. 5	6.5	9.5	7	7.7	0
Paint No. 6	7	9.5	0	5.5	..
Paint No. 7	8.5	10	2	6.8	4
Paint No. 8	6.8	9	10	8.6	4
Paint No. 9	7	9	10	8.7	4
Paint No. 10	8	9	6	7.7	4
Paint No. 11	8.9	9	10	9.3	4
Paint No. 12	7.8	8	5	6.9	2
Paint No. 13	8	8.5	5	7.2	2
Paint No. 14	8.3	8.5	7	7.9	2
Paint No. 15	6.3	8.5	6	6.9	0
Paint No. 16	8.8	8.5	5	7.8	8
Paint No. 17	5.3	7.5	9	7.3	2

FILM CONDITION GRADES:

Paint No. 1	7.3	...	..	...	..
Paint No. 2	7.8	...	..	...	..
Paint No. 3	4.8	...	..	...	..
Paint No. 4	8.5	...	..	...	..
Paint No. 5	3.5	...	...	...	..
Paint No. 6	7.3	...	..	...	..
Paint No. 7	7	...	..	...	..
Paint No. 8	7.8	...	..	...	..
Paint No. 9	7.8	...	..	...	..
Paint No. 10	6	...	..	...	..
Paint No. 11	9	...	..	...	..
Paint No. 12	6.3	...	..	...	..
Paint No. 13	7.5	...	..	...	..
Paint No. 14	6.4	...	..	...	..
Paint No. 15	6.5	...	..	...	..
Paint No. 16	9	...	..	...	...
Paint No. 17	7.3	...	..	...	..

Further details may be obtained from the sub-committee.

Order of Resistance to Fouling:

The paints, based upon the reports in the above table, are listed below, beginning with the best, according to order of resistance to fouling.

PAINT	COMPOSITION
No. 11	Cuprous oxide and HgO yel.
No. 2	Cuprous oxide.
No. 9	Red HgO.
No. 8	Yellow HgO.
No. 14	Copper cyanide and HgO yel.
No. 16	Copper resinate (cuprous oxide) and HgO yel.
No. 5	Copper cyanide.
No. 10	Cupric oxide and HgO yel.
No. 17	Cuprous oxide and HgO yel.
No. 13	Copper carbonate and HgO yel.
No. 12	Paris Green and HgO yel.
No. 15	Copper oleate (cuprous oxide) and HgO yel.
No. 4	Copper carbonate.
No. 7	Copper resinate (and cuprous oxide).
No. 3	Paris Green.
No. 6	Copper oleate (and cuprous oxide).
No. 1	Cupric oxide.

Discussion as to Fouling For Inspections of all 17 Panels.—Of the single toxics, cupric oxide stands out the poorest, with Paris green and copper carbonate also poor. Copper oleate and resinate are extremely poor, even with cuprous oxide present. Cuprous oxide is the only first grade single copper toxic, with copper cyanide not far behind. The mercury oxides stand high, but not better than cuprous oxide.

Of the double toxics (with mercury), naturally cuprous oxide would lead with copper cyanide following. The position of copper resinate is doubtless due to the cuprous oxide present. The position of cuprous oxide and red mercury oxide is strongly subject to objection; likewise, that of cupric oxide and yellow mercury oxide. If the latter can be verified by other tests, it would have an important bearing on the use of scale copper oxide in commercial paints.

The test as a whole points to the advantage of a combination of copper and mercury.

Respectfully submitted on behalf of the sub-committee,

A. M. MUCKENFUSS,
Chairman.

REPORT OF SUB-COMMITTEE XXV ON CELLULOSE ESTER COATINGS

Sub-Committee XXV has held two meetings during the past year, both of them well attended. Considerable progress has been made on methods of testing soluble nitrocellulose and pigments for use in lacquer, and it is hoped that these methods can be ready for submission to the Society in 1928. Progress has been made on the testing of resins for lacquers, but the work is in a less advanced stage. It is recognized that the testing of finished lacquers is the most important problem before the sub-committee, and while much work has been done along this line, it will probably be some time before methods will be ready for submission.

At this time the sub-committee recommends for publication as a tentative standard of the Society the Methods of Sampling and Testing Lacquer Solvents and Diluents appended hereto.[1]

Respectfully submitted on behalf of the sub-committee,

WAYNE R. FULLER,
Chairman.

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[1] See p. 870.—ED.

REPORT OF COMMITTEE D-2
ON
PETROLEUM PRODUCTS AND LUBRICANTS

Committee D-2 on Petroleum Products and Lubricants has held three regular meetings during the past year (in June at Atlantic City, in October at Cleveland and in March at Baltimore), and also, in accordance with its usual practice, an informal meeting in December at Tulsa, Okla., at the time of the annual meeting of the American Petroleum Institute.

Two new sub-committees have been formed this year, as follows:

XXVIII[1] on Autogenous Ignition of Petroleum Products.

Special Sub-Committee on Gravity of Petroleum Products, for the purpose of preparing a new tentative method for the determination of the A. P. I. gravity of petroleum products and lubricants. It is expected that this sub-committee will complete its work during the coming year.

A new feature of the work of the committee is represented by a discussion of the considerations involved in the preparation of specifications for domestic oil fuel and by proposed forms of specifications for these fuels. This material is presented as an appendix to this report.

Two methods of test now being investigated by sub-committees are included as appendices to the reports of these sub-committees. They are:

(*a*) A proposed method for determining oil in refined and semi-refined wax; and

(*b*) A proposed method for measuring the resistance of mineral oils to oxidation (Sligh method).

The voting membership of this committee now consists of 41 producer and 44 non-producer members.

NEW TENTATIVE METHOD

The committee is presenting for approval for publication as tentative, the following methods:

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[1] The organization of the Sub-Committee on Motor Oils referred to in the 1926 Report of the Committee as Sub-Committee XXVIII has not been completed; consequently this number has been assigned to this new sub-committee.

Methods of Sampling Petroleum and Petroleum Products, submitted by Sub-Committee XV on Sampling and Gaging (A. E. Flowers, chairman), and appended hereto.[1]

RECOMMENDED REVISION OF TENTATIVE METHODS

The committee recommends certain changes in the following methods of test, and upon approval of these revisions, that they be continued as tentative:

1. *Tentative Method of Test for Penetration of Greases* (*D 217 - 26 T*).[2]—Acting upon the recommendation of Sub-Committee I on Petrolatum, endorsed by Committee D-2, that this method be applied also to the determination of the consistency of unworked samples of petrolatum, Sub-Committee IV on Grease has submitted the following revisions:

Title.—Change to read as follows by the addition of the italicized words:

> "Method of Test for Penetration of Greases *and Petrolatum.*"

Section 1.—Add the words "and of petrolatum (unworked)." at the end of this section.

Section 2.—Change from its present form: namely,

> "The method should be applied only to greases which have not been melted after having been poured and cooled during manufacture."

to read as follows:

> "The method shall not be applied to greases which have been melted after having been poured and cooled during manufacture. Petrolatum, however, should be melted, poured into a suitable container and cooled before testing."

Section 3.—In the seventh line, change "grease can" to "container."

Section 8.—Add a new sentence to read as follows:

> "All samples of petrolatum shall be tested for original (unworked) consistency after melting and cooling to the temperature of test."

Section 9.—In the ninth line, change the word "grease" to read "grease or petrolatum."

In the twelfth line, change the word "grease" to read "grease or petrolatum."

In the thirteenth line, insert the word "(petrolatum)" after the word "grease."

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[1] See p. 896.—ED.

[2] *Proceedings*, Am. Soc. Testing Mats., Vol. 26, Part I, p. 834 (1926); also 1926 Book of **A.S.T.M. Tentative Standards**, p. 416.

Section 10.—In the first and third lines, change the word "grease" to read "grease or petrolatum."

Section 11.—In the first line, change the word "grease" to read "grease or petrolatum."

Section 12.—In the sixth line, change the word "grease" to read "grease or petrolatum," in both places where it appears.

Section 13.—In the sixth line, change the word "greases" to read "greases or petrolatums."

2. *Tentative Method of Test for Neutralization Number of Petroleum Products and Lubricants (D 188 - 26 T).*[1]—To clarify the meaning the following slight revisions are recommended, as submitted by Sub-Committee XIII on Neutralization Number and Saponification (H. T. Kennedy, chairman).

Section 4.—In the second line, change the words "weighed accurately" to read "weighed to 0.1 g."

Section 5.—In the second line, change the words "weighed accurately" to read "weighed to 0.1 g."

Section 6.—In the third line, change the words "weighed accurately" to read "weighed to 0.1 g."

Change the first paragraph under "Procedure" from its present form: namely,

> "Procedure: Pour the oil and water in a 500-cc. separatory funnel. Shake vigorously and after oil and water have separated, drain water into a 500-cc. casserole. Add 100 cc. of boiling water to oil and agitate. Drain separated water to casserole. Repeat washing and to the accumulated 100 cc. of water add 1 drop of phenolphthalein. Boil. If solution turns pink add 1 cc. of the indicator and titrate with the sulfuric acid solution until extraction is colorless."

to read as follows:

> "Procedure: Introduce into a 250-cc. separatory funnel 25 to 50 g. of oil weighed to 0.1 g., and add 100 cc. of boiling distilled water. Shake vigorously, and after oil and water have separated, drain the water layer into a 500-cc. casserole. Wash the oil in the separatory funnel twice by vigorously shaking with 50-cc. portions of boiling distilled water, and after separation drain into the casserole. To the accumulated 200 cc. of water add one drop of 1-per-cent phenolphthalein solution. Boil. If the solution turns pink, add 1 cc. of the indicator and titrate with the sulfuric acid solution until the extraction is colorless."

3. *Tentative Method of Test for Cloud and Pour Points of Petroleum Products (D 97 - 25 T).*[2]—A clarification of the method is recommended, as submitted by Sub-Committee XVI on Cloud and Pour Test (R. R. Matthews, chairman), as follows:

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 26, Part I, p. 852 (1926); also 1926 Book of A.S.T.M. Tentative Standards, p. 468.

[2] *Proceedings*, Am. Soc. Testing Mats., Vol. 25, Part I, p. 725 (1925); also 1926 Book of A.S.T.M. Tentative Standards, p. 474.

Section 3.—In the first sentence, change the words "approximately 1¼ in. in inside diameter" to read "1$\frac{3}{16}$ to 1$\frac{5}{16}$ in. in inside diameter."

Change the second sentence to read as follows by the addition of the italicized words and the omission of those in brackets:

> "An ordinary 4-oz. oil sample bottle may be used if [the] *it is within the above requirements, and no* test jar is [not] available."

Section 6.—Change the words "with inside diameter ½ in. greater" to read "with inside diameter ⅜ to ½ in. greater."

Section 12.—In the last sentence of Paragraph (*a*), insert the word "upper" before "maximum" and place the latter word in parentheses.

In the first sentence of Paragraph (*b*), insert the word "lower" before "minimum" and place the latter word in parentheses.

Change Paragraph (*c*) from its present form: namely,

> "The pour point of such oils shall be reported as lying between the maximum and minimum pour points (*e.g.*, Pour Point 35°/50° F.)."

to read as follows:

> "The upper and lower pour points shall be reported separately."

4. *Tentative Method of Test for Detection of Free Sulfur and Corrosive Sulfur Compounds in Gasoline (D 130 - 22 T).*[1]—A slight revision is recommended, as submitted by Sub-Committee XVII on Gasoline (T. G. Delbridge, chairman), as follows:

Section 4.—Change the words "shows no" in Paragraph (*a*) to read "shows not more than extremely slight."

In Paragraph (*b*), change the words "shows discoloration" to read "shows more than extremely slight discoloration."

5. *Tentative Method of Test for Carbon Residue of Lubricants (D 189 - 24 T).*—A revision of this method in the form of a complete rewriting of the method is recommended, as submitted by Sub-Committee XXIII on Carbon Residue, and appended hereto.[2] The revision consists principally of a more detailed description of the apparatus and of the method of carrying out the test. See also the report of this sub-committee.

ADVANCEMENT OF TENTATIVE METHODS TO STANDARD

The committee recommends the submission of the following tentative methods to letter ballot of the Society for adoption as standard:

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 22, Part I, p. 780 (1922); also 1926 Book of A.S.T.M. Tentative Standards, p. 456.

[2] See p. 915.—ED.

1. *Tentative Method of Analysis of Grease (D 128 - 26 T)*,[1] slightly modified in accordance with recommendations of Sub-Committee IV on Grease, as follows:

Section 16.—In the thirteenth line, change the word "separator" to read "beaker."

Figure 1.—Delete the comma between the words "potash" and "soap" in the line below the first "Alcoholic Sol'n = (D)."

Section 18.—Add a footnote referring to the figure "100" which appears at the end of this section to read as follows:

> "A close approximation to the amount of glycerin present may be calculated and included in the analysis, by taking 11.0 per cent of the weight of the fatty acids from soaps, providing, of course, that the grease was made from neutral fats."

Section 19.—Add a footnote referring to the word "acid" which appears as the last word of this section, to read as follows:

> "Multiplying the weight of fatty acid by 1.045 gives a very close approximation of the weight of fat from which it was derived. This factor varies very little with the molecular weight of the fat."

2. *Tentative Method of Test for Sulfur in Petroleum Oils Heavier than Illuminating Oil (D 129 - 22 T)*.[2]

3. *Tentative Method of Test for Distillation of Gasoline, Naphtha, Kerosine, and Similar Petroleum Products (D 86 - 26 T)*.[3]

4. *Tentative Method of Test for Steam Emulsion of Lubricating Oils (D 157 - 23 T)*,[4] slightly modified in accordance with recommendations of Sub-Committee XI on Turbine Oils, as follows:

Section 2.—Change to read as follows by the addition of the italicized words and the omission of those in brackets:

> "The [Modified Resistance to Emulsification Number (A.S.T.M. R.E.)] *Steam Emulsion Number (A.S.T.M.—S.E.)* is the number of [minutes] ***seconds*** required for an oil to separate when emulsified and separated under definitely prescribed conditions."

Figure 1.—Change the first phrase of the title to read "Apparatus for Steam Emulsion Test."

Section 11.—In the ninth line, insert the words, "at least" after the word "examined."

Section 13.—Change to read as follows by the addition of the italicized words and the omission of those in brackets:

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 26, Part I, p. 825 (1926); also 1926 Book of A.S.T.M. Tentative Standards, p. 407.

[2] *Proceedings*, Am. Soc. Testing Mats., Vol. 22, Part I, p. 777 (1922); also 1926 Book of A.S.T.M. Tentative Standards, p. 453.

[3] *Proceedings*, Am. Soc. Testing Mats., Vol. 26, Part I, p. 816 (1926); also 1926 Book of A.S.T.M. Tentative Standards, p. 388.

[4] *Proceedings*, Am. Soc. Testing Mats., Vol. 23, Part I, p. 685 (1923); also 1926 Book of A.S.T.M. Tentative Standards, p. 460.

"Results shall be reported, [in minutes and half minutes] *to the nearest second*, of the time necessary for complete (20 cc.) oil separation. The time in [minutes and half minutes] *seconds* shall be reported as the [R. E. Number], *Steam Emulsion Number* A.S.T.M. Method (*S.E. No.*——). In cases where the required volume shall not have separated in 20 minutes, the oil shall be reported as having an [R. E. Number, A.S.T.M. Method, of 20 plus] *S.E. Number, A.S.T.M. Method of 1200 plus*. If *a* duplicate [determinations vary] *determination varies* by more than [one minute] *10 per cent*, a third test shall be made and the average of the three tests reported."

Change the last sentence in the Note to read as follows:

"The S. E. number is derived from the top layer."

Section 14.—Omit this section, reading as follows:

"With care and proper attention to details, duplicate determinations of the R. E. Number, A.S.T.M. Method, should not differ by more than 0.5"

5. *Tentative Method of Test for Burning Quality of Kerosine Oils (D 187 - 24 T).*[1]

6. *Tentative Method of Test for Burning Quality of Long-Time Burning Oil for Railway Use (D 219 - 26 T).*[2]

7. *Tentative Method of Test for Burning Quality of Mineral Colza Oil (D 239 - 26 T).*[2] A modification in the title is recommended, as submitted by Sub-Committee XIX on Illuminating Oils (J. B. Rather, chairman), as follows:

Title.—Change to read "Mineral Seal Oil" instead of "Mineral Colza Oil."

8. *Tentative Method of Test for Distillation of Natural Gas Gasoline (D 216 - 25 T).*[3]

9. *Tentative Method of Test for Thermal Value of Fuel Oil (D 240 - 26 T)*,[4] with slight revisions, submitted by Sub-Committee XXIV on Calorific Value (R. W. Savidge, chairman), as follows:

Section 2.—Change to read as follows by the addition of the italicized words and the omission of those in brackets:

"The calorimeter shall be provided with a *vacuum jacket or with a* water jacket having a cover to protect the calorimeter from air currents. [The jacket] *In case a water jacket is used, it* shall be kept filled with water within 2 or 3° C. of the temperature of the room (except in calorimeters which are totally submerged, where the jacket temperature is controlled by a thermostat) and *this water* should be stirred continuously by some mechanical stirring device."

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 24, Part I, p. 888 (1924); also 1926 Book of A.S.T.M. Tentative Standards, p. 435.

[2] *Proceedings*, Am. Soc. Testing Mats., Vol. 26, Part I, pp. 840–847 (1926); also 1926 Book of A.S.T.M. Tentative Standards, pp. 441–448.

[3] *Proceedings*, Am. Soc. Testing Mats., Vol. 25, Part I, p. 693 (1925); also 1926 Book of A.S.T.M. Tentative Standards, p. 397.

[4] *Proceedings*, Am. Soc. Testing Mats., Vol. 26, Part I, p. 855 (1926); also 1926 Book of A.S.T.M. Tentative Standards, p. 487.

RECOMMENDED AMENDMENT OF STANDARD METHOD

The committee recommends the following amendments of standard methods to become effective immediately. It accordingly asks for the necessary nine-tenths vote.

Standard Method of Test for Water in Petroleum Products and Other Bituminous Materials (D 95 - 24).[1]—Amendments are recommended, as submitted by Sub-Committee XIV on Water and Sediment (H. R. Gundlach, chairman) as follows:

Figure 1.—Change the vertical dimension of the copper still from 6 in. to 6.0 in. ±0.25 in., and the diameter from $3\frac{3}{4}$ in. to 3.7 in. ±0.2 in.

Insert after dimension *H*, the words "(Inside Diameter)."

WITHDRAWAL OF STANDARD METHOD

The committee recommends the withdrawal of the Standard Method of Test for Specific Gravity of Lubricants (D 47 - 24).[1]

Appended hereto are reports of the following sub-committees:

Sub-Committee I on Petrolatum;
Sub-Committee III on Paraffin Wax;
Sub-Committee IV on Grease;
Sub-Committee VII on Sulfur Determination and Differentiation;
Sub-Committee IX on Precipitation;
Sub-Committee X on Oxidation at High Temperatures;
Sub-Committee XI on Turbine Oils;
Sub-Committee XXIII on Carbon Residue;
Sub-Committee XXV on Crankcase Dilution;
Sub-Committee XXVII on Application of Tests.

The recommendations appearing in this report, with the exception of items 2 and 3 under Recommended Revision of Tentative Methods, have been submitted to letter ballot of the committee, which consists of 85 members; 47 ballots have been returned, and 38 members have refrained from voting. The result of the letter ballot is as follows:

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[1] 1924 Book of A.S.T.M. Standards.

Items	Affirmative	Negative	Not Voting
I. PROPOSED NEW TENTATIVE METHOD			
Methods of Sampling Petroleum and Petroleum Products	43	1	3
II. RECOMMENDED REVISION OF TENTATIVE METHODS			
1. Method of Test for Penetration of Greases (D 217 - 26 T)	43	0	4
4. Method of Test for Detection of Free Sulfur and Corrosive Sulfur Compounds in Gasoline (D 130 - 22 T)	44	0	3
5. Method of Test for Carbon Residue of Lubricants (D 189 - 24 T)	44	0	3
III. ADVANCEMENT OF TENTATIVE METHODS TO STANDARD			
1. Method of Test for Analysis of Grease (D 128 - 26 T), as revised	40	1	6
2. Method of Test for Sulfur in Petroleum Oils Heavier Than Illuminating Oil (D 129 - 22 T)	40	1	6
3. Method of Test for Distillation of Gasoline, Naphtha, Kerosine, and Similar Petroleum Products (D 86 - 26 T)	45	0	2
4. Method of Test for Steam Emulsion of Lubricating Oils (D 157 - 23 T), as revised	40	2	5
5. Method of Test for Burning Quality of Kerosine Oils (D 187 -24 T)	40	1	6
6. Method of Test for Burning Quality of Long-Time Burning Oil for Railway Use (D 219 - 26 T)	41	0	6
7. Method of Test for Burning Quality of Mineral Colza Oil (D 239 - 26 T), as revised	40	0	7
8. Method of Test for Distillation of Natural Gas Gasoline (D 216 - 25 T)	43	0	4
9. Method of Test for Thermal Value of Fuel Oil (D 240 - 26 T), as revised	42	1	4
IV. RECOMMENDED AMENDMENT OF STANDARD METHOD			
Method of Test for Water in Petroleum Products and Other Bituminous Materials (D 95 - 24)	42	0	5
V. WITHDRAWAL OF STANDARD METHOD			
Method of Test for Specific Gravity of Lubricants (D 47 - 24)	45	0	2

This report has been submitted to letter ballot of the committee, which consists of 85 members, of whom 46 have voted affirmatively, none negatively, and 39 have refrained from voting.

Respectfully submitted on behalf of the committee,

F. A. HULL,
Chairman.

R. P. ANDERSON,
Secretary.

EDITORIAL NOTE

The Tentative Methods of Analysis of Grease; Test for Steam Emulsion of Lubricating Oils; for Burning Quality of Mineral Colza Oil; and for Thermal Value of Fuel Oil, were approved at the annual meeting as revised by the committee and were subsequently adopted by letter ballot of the Society on September 1, 1927. The methods as revised appear in the 1927 Book of A.S.T.M. Standards, Part II. The Tentative Method of Test for Sulfur in Petroleum Oils Heavier than Illuminating Oil; for Distillation of Gasoline, Naphtha, Kerosine, and Similar Petroleum Products; for Burning Quality of Kerosine Oils; for Burning Quality of Long-Time Burning Oil for Railway Use; and for Distillation of Natural Gas Gasoline, were approved at the annual meeting as recommended by the committee and were subsequently adopted by letter ballot of the Society on September 1, 1927. The methods appear in the 1927 Book of A.S.T.M. Standards, Part II.

The proposed revisions of the Standard Method of Test for Water in Petroleum Products and Other Bituminous Materials were approved at the annual meeting by a nine-tenths vote and were subsequently adopted by letter ballot of the Society on September 1, 1927. The methods as revised appear in the 1927 Book of A.S.T.M. Standards, Part II.

The proposed Tentative Methods of Sampling Petroleum and Petroleum Products were accepted for publication as tentative and appear on page 896.

The proposed revisions of the Tentative Methods of Test for Penetration of Greases; for Detection of Free Sulfur and Corrosive Sulfur Compounds in Gasoline; and for Carbon Residue of Lubricants, were accepted. The tentative methods as revised appear on pages 930, 926 and 915, respectively. The proposed revisions of the Tentative Methods of Test for Neutralization Number of Petroleum Products and Lubricants; and for Cloud and Pour Points of Petroleum Products, submitted on the floor of the meeting without having been referred to letter ballot of the committee, were accepted by unanimous vote. The tentative methods as revised appear on pages 927 and 919, respectively.

The withdrawal of the Standard Method of Test for Specific Gravity of Lubricants was approved.

REPORT OF SUB-COMMITTEE I ON PETROLATUM

Four samples of petrolatum were sent out for tests of unworked consistency by means of the A.S.T.M. Tentative Method of Test for Penetration of Greases (D 217 - 26 T), and for melting point by two methods, namely, the plate method[1] and the A.S.T.M. Tentative Method of Test for Melting Point of Petrolatum (D 127 - 24 T). The samples were intended to represent (1) normal consistency and melting point, (2) hard, low melting point, (3) soft, low melting point, and (4) hard, high melting point. Sample No. 3 was made by the addition of oil to No. 2.

TABLE I.—CONSISTENCY AND MELTING POINT OF PETROLATUM.

Laboratory	Sample No. 1	Sample No. 2	Sample No. 3	Sample No. 4
CONSISTENCY BY GREASE PENETRATION METHOD				
No. 1	213	198	325	167
No. 2	196	162	295+	148
No. 3	198	165	...	146
No. 4	199	177	307	147
No. 5	200	166	279	151
No. 6	213	186	299	157
MELTING POINT, A.S.T.M. METHOD, DEG. FAHR.				
No. 1	117.1	112.7	115.3	127.8
No. 2	116.1	112.8	114.1	126.6
No. 3	120.5	116.6	117.2	129.3
No. 4	115.3	112.1	110.3	126.3
No. 5	118.3	112.7	113.9	130.1
No. 6	116.3	112.3	116.5	127.1
MELTING POINT, PLATE METHOD, DEG. FAHR.				
No. 1	115.5	113.0	112.8	127.3
No. 2	110.5	111.5	106.0	122.5
No. 3	109.9	111.9	108.3	123.2
No. 4	113.0	112.1	107.7	124.3
No. 5	114.1	112.3	110.0	125.1
No. 6	115.1	111.8	108.6	126.4

As shown in Table I, sample No. 1 is softer than No. 2 but has a higher melting point, which indicates that consistency and melting point vary independently.

Table II, calculated from the data of Table I, shows the difference in melting point as determined by the two methods. Except in two cases, the higher value was always obtained by the A.S.T.M. method.

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 21, p. 357 (1921).

TABLE II.—DIFFERENCE OF MELTING POINT TEMPERATURES OBTAINED WITH A.S.T.M. METHOD ABOVE VALUES OBTAINED BY PLATE METHOD, DEG. FAHR.

LABORATORY	SAMPLE No. 1	SAMPLE No. 2	SAMPLE No. 3	SAMPLE No. 4
No. 1	1.6	−0.3	3.0	0.5
No. 2	5.6	1.3	8.1	4.1
No. 3	10.6	4.7	8.9	6.1
No. 4	2.3	0.0	2.6	2.0
No. 5	4.2	0.4	3.9	5.0
No. 6	1.2	0.5	7.9	0.7

It is noticeable that different laboratories obtained better agreement with sample No. 2 than with the other three samples. As regards the agreement between laboratories, the difference between the maximum and the minimum values for melting point are given in Table III.

TABLE III.—DIFFERENCE BETWEEN MAXIMUM AND MINIMUM MELTING POINT DETERMINATIONS, DEG. FAHR.

	SAMPLE No. 1	SAMPLE No. 2	SAMPLE No. 3	SAMPLE No. 4	AVERAGE
Plate Method	5.6	1.5	6.8	4.8	4.7
A.S.T.M. Method	5.2	4.5	6.9	3.8	5.1

Here also better agreement is shown in the case of sample No. 2, possibly because it is more homogeneous than the others. The table also shows slightly better concordance with the plate method than with the A.S.T.M. method.

As a result of the data obtained on the use of the Tentative Method of Test for Penetration of Greases (D 217 - 26 T)[1] on petrolatum, it is recommended that this method be approved as a tentative method for consistency of unworked samples of petrolatum.

Respectfully submitted on behalf of the sub-committee,

WINSLOW H. HERSCHEL,
Chairman.

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 26, Part I, p. 834 (1926); also 1926 Book of A.S.T.M. Tentative Standards, p. 416

REPORT OF SUB-COMMITTEE III ON PARAFFIN WAX

Previous work by the sub-committee has shown that the old press method for determining oil in paraffin wax cannot be standardized, and that the Solvent Index of Refraction Method, as developed by Wilson and Wilkin, offered the best means heretofore available for this determination. For the operation of the Solvent Index of Refraction Method it is necessary to know the refractive indices of the oil and of the wax in the residue. These refractive indices may vary with the crude source of the wax, and for the method to apply universally it would be necessary to have this information on refractive index for all crude oils. Obviously to prepare such a body of data would entail a prohibitive amount of labor.

In view of this, a systematic investigation was conducted in the chairman's laboratory to develop a method which would have the advantages of the Solvent Index of Refraction Method without its disadvantages. After attempting to develop solvent-gravimetric procedures, a procedure based on the solidification point of the extracted oil and one based on the sweating of a cake of wax under prescribed conditions, a method was developed which, in the chairman's laboratory, has given entirely satisfactory results in the hands of a number of operators.

The theory of this method may be outlined as follows:

It has been shown by Wilson and Wilkin that by the proper use of ethylene dichloride as a solvent a weighable residue may be obtained which contains all the oil of a given sample of wax plus an amount of wax of the same order of magnitude. The present method consists in starting with such a residue of oil and wax, determining the weight of the wax by its effect on the solidification point of a light paraffin oil, and calculating the oil by difference. This involves the use of a calibration curve which relates rise in solidification point of the paraffin oil to known additions of wax. Since the wax obtained in residues from samples of different origin does not always affect the solidification point uniformly, advantage is taken of the fact that the wax obtained by a second extraction of a given sample with ethylene dichloride is identical in effect on the solidification point with that obtained in the first extraction. Accordingly, a calibration curve developed by determining the solidification point of the "reagent" paraffin oil and the effect of the wax obtained in the second ethylene dichloride extraction of a given sample on the solidification point of this oil, eliminates as an independent variable the nature of the wax in the oil-wax residue obtained in the first extraction with ethylene dichloride. This involves the making of a calibration curve for each determination of oil in a given sample of wax, which, however, adds only slightly to the time required for making the test.

The method in question, which was developed by H. F. Weide of the chairman's laboratory, was sent to all members of the sub-committee on January 19, and is appended to this report. With the procedure were supplied three samples of wax containing added oil, one 4-oz. bottle of "reagent" paraffin oil, large and small test tubes and thermometer as called for in the procedure. It was requested that oil determinations be made by the proposed method and by the Solvent Index of Refraction Method on the samples submitted. Results reported to date are shown in Table I.

TABLE I.—RESULTS OF TESTS ON DETERMINATION OF OIL IN WAX OF VARYING OIL CONTENT.

Laboratory	Operator	Sample A			Sample B			Sample C		
		Added Oil, per cent	Found by Solvent Index of Refraction Method, per cent	Found by Solidification Point Method, per cent	Added Oil, per cent	Found by Solvent Index of Refraction Method, per cent	Found by Solidification Point Method, per cent	Added Oil, per cent	Found by Solvent Index of Refraction Method, per cent	Found by Solidification Point Method, per cent
No. 1	I	0.5	0.51	0.62	4.0	3.84	4.05	1.8	1.92	2.08
		...	....	0.75	...	....	4.02	...	....	2.19
	II	...	....	0.67	...	....	4.09	...	....	1.98
		...	....	0.81	...	....	4.00	...	....	2.03
No. 2	I	...	0.76	0.60	...	2.01	3.86	...	1.31	2.49
	II	...	0.63	1.10	...	2.69	3.21	...	1.54	2.22
No. 3	......	...	0.50	0.92	...	2.40	4.03	...	....	2.09
		...	0.67	0.95	...	2.65	2.43	...	....	2.31
		...	....	....	...	....	1.97	...	....	....
		...	....	....	...	....	2.55	...	....	....
No. 4	......	...	....	1.12	...	....	3.87	...	....	2.00
		...	....	0.92	...	....	4.06	...	....	2.07
		...	....	....	...	....	4.11	...	....	2.25
		...	....	....	...	....	....	...	....	2.22
No. 5	[a]	...	0.15	0.85	...	2.44	4.21	...	1.19	2.46
		...	0.20	0.73	...	2.35	4.06	...	1.15	2.66
	[b]	...	0.59	....	...	3.87	....	...	2.12	....
		...	0.68	....	...	3.93	....	...	2.02	....
No. 6	......	...	0.63	0.83	...	2.87	3.84	...	2.6	2.13
		...	0.94	0.83	...	3.14	4.34	...	2.1	2.24

[a] Values obtained by using Wilson Indices of Refraction.

[b] Values obtained by Indices of Refraction determined on Sample B in Laboratory No. 5.

The sub-committee presents for information and criticism the proposed method for the determination of oil in paraffin wax in the hope that it will be possible to recommend either it or the Solvent Index of Refraction Method as a tentative method of test at the 1928 meeting of the Society.

Respectfully submitted on behalf of the sub-committee,

J. B. RATHER,
Chairman.

APPENDIX

PROPOSED METHOD OF DETERMINING OIL IN REFINED AND SEMI-REFINED WAX

1. *Scope.*—This method covers the determination of the percentage of oil in refined and semi-refined waxes irrespective of the crude oil source.

Apparatus

2. *Filtration Apparatus* (*Holde Type*).—As a suction filter any suitable set-up may be used which will allow prolonged suction filtration at 0° F.

3. (*a*) *Solidification Point Apparatus. Thermometer.*—The thermometer shall be 12 in. over all in length, the temperature range −20 to + 120° F., graduated in degrees Fahrenheit, the bulb length ¾ in.

(*b*) *Small Test Tube.*—The small test tube shall be 6 in. in length and ¾ in. in diameter. The thermometer shall rest on the bottom of the test tube and shall be held rigidly at the top of the test tube by means of a cork.

(*c*) *Large Test Tube.*—The large test tube shall be 6 in. in length and 1¼ in. in diameter. The small test tube shall stand inside the large test tube with uniform distance separating them at all points including the bottom.

(*d*) *Cooling Bath.*—The cooling bath shall be capable of holding the large test tube in an ice-salt mixture, and shall be capable of maintaining a temperature of 0° F. for long periods.

Reagents

4. *Ethylene Dichloride.*—The ethylene dichloride shall be an 85-per-cent intermediate cut from the technically pure grade of solvent.

5. *Paraffin Oil.*—The standard paraffin oil shall conform to the following requirements:

Gravity, A. P. I.	30.90
Flash point	270° F.
Fire point	305° F.
Viscosity at 100° F.	48.0
Color, A.S.T.M.	1¾
Solid point	13° F.

The solid point shall be taken with the solidification point apparatus in accordance with the procedure described in Sections 6 and 7.

Procedure

6. *Sample.*—Suitable precaution shall be exercised in obtaining a representative sample of the wax for test, by melting several hundred grams, stirring, and pouring approximately 10 g. into a weighed Erlenmeyer flask. Samples for duplicate runs shall be poured immediately. The temperature of the melted wax must never be above 160° F.

7. *Test for Oil Content.*—The weight of the poured sample shall be determined accurately. Approximately 100 cc. of warm ethylene dichloride shall be added, and the Erlenmeyer flask agitated until the sample is dissolved. The sample shall then be cooled to 0° F. ± 3° F. in an ice-salt mixture, stirring the solution with a thermometer during cooling to facilitate pouring from the flask.

The contents of the flask shall then be poured into the suction filter, which has been prepared previously and which is at about 0° F. A satisfactory suction filter may be made by cutting the bottom out of a 1-gal. ether can and inverting it for the filter bath. The filter proper may be made by sealing a 1½-in. glass tube to a ¼-in. tube, and adjusting a perforated Gooch disk with asbestos.

When all the wax has been poured into the suction filter, the flask shall be washed with ethylene dichloride previously cooled to 0° F. The washings from the flask shall be added to the wax on the filter and filtration continued until the filtrate and washings amount to approximately 200 cc. The wax shall be left on the filter.

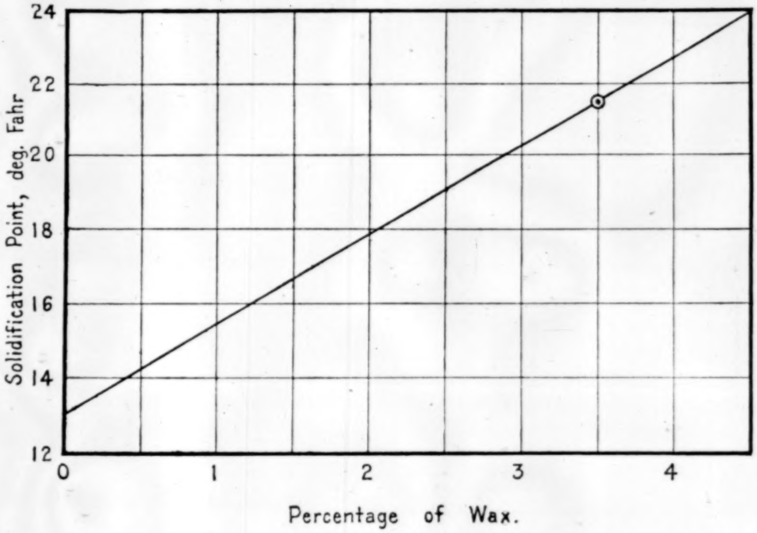

FIG. 1.—Calibration Curve Showing Relation Between Solidification Point and Percentage of Wax.

The filtrate shall be filtered through paper into a tared beaker. The beaker shall be placed on a water bath and the solvent evaporated under a stream of filtered dry air. The evaporation shall be prolonged 2½ minutes beyond the disappearance of the characteristic odor of ethylene dichloride. The beaker should then contain a residue consisting of all the oil in the original wax sample and a certain amount of wax.

After the beaker has cooled 10 minutes it shall be weighed and the weight of the residue recorded. Approximately 6 g. of paraffin oil shall then be added to the beaker containing the residue, the exact weight of the paraffin oil being recorded. The beaker shall be warmed gently on the water bath and the contents thoroughly mixed. Enough of the mixture shall then be added to the small test tube to cover the bulb of the thermometer ¼ in. The bulb of the thermometer must touch the bottom of the test tube. The small test tube shall then be placed in the large test tube which stands in the cooling bath. As the solidification point is approached the oil shall be examined at every half degree change in temperature and that temperature recorded as the solid point at which the oil has just solidified and at which it will not pour when the test tube is held in a sloping position. The allowable error in determining the solid point shall be ½° F.

The wax left on the filter shall be dissolved in about 150 cc. of hot ethylene dichloride. This may be accomplished easily by replacing the ice-salt mixture of the filter bath by hot water, pouring the hot ethylene dichloride onto the wax and stirring to accelerate solution. When all the wax has been redissolved, the solution shall be cooled to 0° F. and filtered again at 0° F., 200 cc. of filtrate and washings being collected as before.

The filtrate and washings shall be treated as the filtrate and washings of the first filtration, recording the weight of the residue, the weight of the paraffin oil added, and the solid point. This evaporation residue shall be considered as pure wax. A calibration curve shall be constructed using percentage of wax as the abscissa against solidification temperature in degrees Fahrenheit as the ordinates. The curve will be a straight line and the second point will be the solidification temperature of the pure paraffin oil.

The solid point obtained with the solution of the first filtrate residue shall be located on this curve and the percentage of wax in the contents of the first tared beaker after the addition of the paraffin oil found thereby. This figure multiplied by the recorded weight of the first residue plus paraffin oil, gives the weight of wax in the first residue. The first residue consists of wax and oil. The weight of the residue minus the weight of the wax gives directly the weight of oil present in the original wax sample.

Separate calibration curves for duplicate runs sometimes coincide and sometimes diverge; therefore, a separate calibration curve for each duplicate run shall be made. It is sometimes found that averaging the calibration curves gives better agreement of the final result. If such is the case, that procedure is permissible.

Example.—

Weight of sample taken	9.8765 g.
Weight of first residue (wax + all the oil)	0.2940 g.
Weight of first residue + added paraffin oil	6.3471 g.
Solidification point of the mixture	18.5° F.
Weight of second residue (wax only)	0.2245 g.
Weight of second residue + added paraffin oil	6.4143 g.
Percentage of wax in the mixture (second residue)	3.5
Solidification point of the pure paraffin oil	13.0° F.
Solidification point of the second mixture	21.5° F.

From the calibration curve (see Fig. 1), 18.5° F. shows 2.25 per cent of wax to be present in the first residue plus paraffin oil.

$6.3471 \times 0.0225 = 0.1428$ g. of wax in the first residue.

$0.2940 - 0.1428 = 0.1512$ g. of oil in the first residue, and in the original sample.

$$\frac{0.1512}{9.8765} \times 100 = 1.53 \text{ per cent of oil in the wax.}$$

REPORT OF SUB-COMMITTEE IV ON GREASE

The work of the Sub-Committee on Grease during the year has been devoted mainly to checking up on the Tentative Methods of Analysis of Grease (D 128 – 26 T) in comparison with certain other suggested methods and attempting to develop a method for the melting point or flow point of grease. It has been found that while some of the proposed analytical methods might be desirable short cuts for a narrow class of greases, they do not have the accuracy or the general applicability to a wide variety of greases which is necessary for a general or referee method, and which is possessed by the present tentative method.

With respect to a method for the melting point or flow point of grease, extensive work has shown that:

1. The results obtained depend very greatly on the shearing stresses applied;
2. Methods involving slipping on an inclined heated surface are sometimes deceptive due to the separation of a film of oil from the grease; and
3. None of the methods thus far tried appears to be free from objection.

It is recommended that work be continued with particular emphasis on the desirability of developing a method which bears a real relationship to service conditions.

For recommendations of the sub-committee on the Tentative Methods D 128 – 26 T and D 217 – 26 T, see the body of the report of Committee D-2.

Respectfully submitted on behalf of the sub-committee,

R. E. Wilson,
Chairman.

test tube to cover the bulb of the thermometer $\frac{1}{4}$ in. The bulb of the thermometer must touch the bottom of the test tube. The small test tube shall then be placed in the large test tube which stands in the cooling bath. As the solidification point is approached the oil shall be examined at every half degree change in temperature and that temperature recorded as the solid point at which the oil has just solidified and at which it will not pour when the test tube is held in a sloping position. The allowable error in determining the solid point shall be $\frac{1}{2}$° F.

The wax left on the filter shall be dissolved in about 150 cc. of hot ethylene dichloride. This may be accomplished easily by replacing the ice-salt mixture of the filter bath by hot water, pouring the hot ethylene dichloride onto the wax and stirring to accelerate solution. When all the wax has been redissolved, the solution shall be cooled to 0° F. and filtered again at 0° F., 200 cc. of filtrate and washings being collected as before.

The filtrate and washings shall be treated as the filtrate and washings of the first filtration, recording the weight of the residue, the weight of the paraffin oil added, and the solid point. This evaporation residue shall be considered as pure wax. A calibration curve shall be constructed using percentage of wax as the abscissa against solidification temperature in degrees Fahrenheit as the ordinates. The curve will be a straight line and the second point will be the solidification temperature of the pure paraffin oil.

The solid point obtained with the solution of the first filtrate residue shall be located on this curve and the percentage of wax in the contents of the first tared beaker after the addition of the paraffin oil found thereby. This figure multiplied by the recorded weight of the first residue plus paraffin oil, gives the weight of wax in the first residue. The first residue consists of wax and oil. The weight of the residue minus the weight of the wax gives directly the weight of oil present in the original wax sample.

Separate calibration curves for duplicate runs sometimes coincide and sometimes diverge; therefore, a separate calibration curve for each duplicate run shall be made. It is sometimes found that averaging the calibration curves gives better agreement of the final result. If such is the case, that procedure is permissible.

Example.—

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$6.3471 \times 0.0225 = 0.1428$ g. of wax in the first residue.

$0.2940 - 0.1428 = 0.1512$ g. of oil in the first residue, and in the original sample.

$$\frac{0.1512}{9.8765} \times 100 = 1.53$$ per cent of oil in the wax.

REPORT OF SUB-COMMITTEE IV ON GREASE

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With respect to a method for the melting point or flow point of grease, extensive work has shown that:

1. The results obtained depend very greatly on the shearing stresses applied;
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3. None of the methods thus far tried appears to be free from objection.

It is recommended that work be continued with particular emphasis on the desirability of developing a method which bears a real relationship to service conditions.

For recommendations of the sub-committee on the Tentative Methods D 128 - 26 T and D 217 - 26 T, see the body of the report of Committee D-2.

Respectfully submitted on behalf of the sub-committee,

R. E. Wilson,
Chairman.

REPORT OF SUB-COMMITTEE VII ON SULFUR DETERMINATION AND DIFFERENTIATION

At the meeting of Committee D-2 in June, 1926, Sub-Committee VII was directed to continue the comparison of the Tentative Method of Test for Sulfur in Naphthas and Illuminating Oils (D 90 - 26 T) with the Kennedy Vapor Lamp method. The following motor fuels were prepared for this purpose. samples of which were distributed to the members of the sub-committee:

TABLE I.—RESULTS OF TESTS ON SULFUR DETERMINATION BY A.S.T.M. METHOD D 90 - 26 T AND KENNEDY VAPOR LAMP METHOD.

	Sulfur, Per Cent					
	Sample No. 8		Sample No. 9		Sample No. 10	
	A.S.T.M. Method	Kennedy Vapor Lamp Method	A.S.T.M. Method	Kennedy Vapor Lamp Method	A.S.T.M. Method	Kennedy Vapor Lamp Method
Laboratory No. 1	0.050	0.040	0.216	0.220	0.218	0.226
	0.087	0.042	0.210	0.215	0.219	0.223
Average	0.068	0.041	0.213	0.218	0.219	0.225
Laboratory No. 2	0.055	0.046	0.230	0.200	0.230	0.220
	0.050	0.044	0.210	0.220	0.220	0.220
	0.050	.....	0.220	.....	.....	0.220
Average	0.052	0.045	0.220	0.210	0.225	0.220
Laboratory No. 3	0.030	0.041	0.218	0.218	0.219	0.226
	0.037	0.041	0.214	0.221	0.215	0.221
	0.031	0.038	0.221	0.216	0.221	0.223
	.....	.....	0.227	.....	.....	.....
	.....	.....	0.216	.....	.....	.....
Average	0.033	0.040	0.219	0.218	0.218	0.223
Laboratory No. 4	0.050	0.031	0.222	0.196	0.223	0.220
	0.049	0.033	0.222	0.200	0.222	0.219
Average	0.050	0.032	0.222	0.198	0.223	0.220
Laboratory No. 5	0.044	0.051	0.221	0.221	0.220	0.226
	0.040	0.049	0.202	0.217	0.218	0.230
Average	0.042	0.050	0.212	0.219	0.219	0.228
Laboratory No. 6	0.027	0.025	0.170	0.200	0.180	0.210
	0.038	0.037	0.170	0.190	0.210	0.210
	0.027	0.041	0.190	0.180	0.220	0.200
	0.031	0.035	.....	.....	0.220	.....
Average	0.031	0.034	0.177	0.190	0.208	0.207
General average	0.046	0.040	0.211	0.209	0.219	0.220
Average Deviation, plus or minus	0.011	0.007	0.011	0.010	0.004	0.005
Lower results, minus	0.015	0.006	0.034	0.019	0.011	0.013
Highest results, plus	0.022	0.010	0.011	0.010	0.006	0.008

Sample No. 8.—A blend of 70 volumes of low-sulfur gasoline and 30 volumes of c. p. benzene.

Sample No. 9.—A blend of 1529 g. of sample No. 8 with 3.6 g. of redistilled carbon bisulfide. Every precaution was taken to avoid loss of the bisulfide by evaporation. The added bisulfide corresponded to an increase of 0.2 per cent of sulfur.

Sample No. 10.—A blend of 70 volumes of sweet and non-corrosive Mexican gasoline, redistilled with steam, and 30 volumes of c. p. benzene.

The results reported by the members of the sub-committee are given in Tables I and II, and indicate that the examined methods give results that agree quite well.

TABLE II.—SHOWING RESULTS ON RECOVERY OF BISULFIDE

Laboratory	A.S.T.M. Method		Kennedy Vapor Lamp Method	
	Bisulfide, per cent	Per Cent of Total	Bisulfide, per cent	Per Cent of Total
No. 1	0.145	72.5	0.177	88.5
No. 2	0.168	84.0	0.165	82.5
No. 3	0.186	93.0	0.178	89.0
No. 4	0.172	86.0	0.166	83.0
No. 5	0.170	85.0	0.169	84.5
No. 6	0.146	73.0	0.156	78.0
Average	0.165	82.3	0.169	84.3

Attention has been called by members of the Sub-Committee to the following points in connection with Method D 90 - 26 T:

1. The difficulty of maintaining the flame at the prescribed height ($\frac{1}{4}$ in.) with the top of the wick level with the upper end of the wick tube.

2. The desirability of standardizing the apparatus used in Method D 90 - 26 T.

3. The influence of contaminated air upon the results of test by Method D 90 - 26 T and the difficulty of obtaining reliable blanks.

It is suggested that the above points be investigated by the sub-committee in the near future.

Respectfully submitted on behalf of the sub-committee,

ERNST JOHANSEN,
Chairman.

REPORT OF SUB-COMMITTEE IX ON PRECIPITATION

During the work in the chairman's laboratory for the past few months, the following sub-divisions of the committee work have been considered:

1. Work on A.S.T.M. Tentative Method of Test for Precipitation Number;
2. Various tar tests.

The considerations involved are mainly the following:

(*a*) The quality of naphtha used; and

(*b*) The technique of conducting the tests.

It has been demonstrated clearly that work should be concentrated on the quality of the naphtha used and that this factor, rather than the details of the precipitation or tar tests, should be determined carefully as the naphtha specification is the controlling factor.

In Table I are given the results reported in March, 1925, by Mr. Crosby, then chairman of Sub-Committee IX.

On the basis of these results, Mr. Crosby proposed the following requirements for precipitation naphtha:

Initial Boiling Point	150–160° F.
End Point	195–205° F.
Aniline Point	not less than 64.0° C.

The aniline point is measured by pipetting 10 cc. each of the gasoline and aniline into a jacketted test tube fitted with a stirrer and thermometer dipping into the liquid. The mixture is warmed till the liquids give a clear solution and is then allowed to cool with stirring, till the mixture becomes turbid. It is then re-warmed till it just clears again, and is then allowed to cool. The temperature at which turbidity occurs is the aniline point.

The conclusions drawn from this report indicate the apparent impossibility of making a satisfactory precipitation naphtha from anything except Pennsylvania crude oil and also indicate the need for considering the aniline point in naphtha specifications.

The preparation of naphtha, comparable in distillation range to Holde Normal Benzine, from 4 different samples of crude oil has been completed and only in the case of Pennsylvania crude oil has there been any success in securing aniline points approaching in value the requirement of not less than 64° C. This has been true despite the fact that with all the naphthas studied, particular precautions were taken through sulfonation followed by nitration to remove in so far as possible all unsaturated and aromatic compounds. Even with certain samples of Pennsylvania crude oil, the apparent presence of a certain amount of naphthene hydrocarbons, not affected by sulfonation and nitration, prevents the obtaining of a sufficiently high aniline point.

TABLE I.—RESULTS OF TESTS ON NAPHTHA AS REPORTED BY CROSBY, MARCH, 1925.

Grade of Naphtha	Properties of Naphtha				Precipitation Number on Several Samples of Oil		
	Boiling Range		Aniline Point		Cylinder Oil No. 1	Cylinder Oil No. 2	M. C. Black Oil No. 3
	Initial Point, deg. Fahr.	End Point, deg. Fahr.	Before Sulfonation, deg. Cent.	After Sulfonation, deg. Cent.			
1. Mid-Continent (A.S.T.M. requirements)	113	248	61.6	64.5	0.22	0.50	1.45
2. Pennsylvania (A.S.T.M. requirements)	118	248	63.3	66.0	0.23	0.35	1.00
3. California (A.S.T.M. requirements)	128	233	57.7	59.7	0.15	0.30	0.35
4. Mid-Continent (Holde requirements)	155	197	57.7	59.5	0.14	0.35	0.45
5. Pennsylvania (Holde requirements)	157	195	59.7	62.1	0.18	0.30	0.45
6. California (Holde requirements)	156	195	51.0	53.3	0.10	0.05	0.05
7. Imported (Holde requirements)	156	204	65.0	65.5	0.23	0.40	1.10
8. Pennsylvania, supplied by Dean (Holde requirements)	153	205	64.7	66.6	0.23	0.40	1.10

Two new types of fractionating columns permitting a sufficient volume of extremely narrow cuts to be obtained have been built and will be used in further work on the preparation of a satisfactory solvent. Preliminary work with these has confirmed the previous concepts of the importance of the aniline point and has indicated also that the preparation of a naphtha meeting Crosby's requirements, even from Pennsylvania crude oil, is difficult.

Respectfully submitted on behalf of the sub-committee,

L. W. PARSONS,
Chairman.

REPORT OF SUB-COMMITTEE X ON OXIDATION AT HIGH TEMPERATURES

During the past few months this sub-committee has concerned itself with the question of the reproducibility of the oxidation test, Sligh method, developed at the U. S. Bureau of Standards.

A solvent naphtha and samples of six different oils were distributed to thirteen members of the committee for test by this method. The object was to determine the reproducibility obtainable: (1) in a given laboratory; and (2) between different laboratories.

Analysis of the reports received from ten laboratories indicates that while good check results are obtained in the majority of cases, there still exist some wildly erratic results which appear to be due to lack of control of some important detail of the test. In order to obtain further data regarding reproducibility, two more oils and a solvent naphtha will be sent out for intensive work regarding the conditions essential to reproducibility.

The sub-committee realizes that while reproducibility is not the sole requisite for a satisfactory test, it is an essential pre-requisite to the evaluation of the significance of any test.

A description of the method revised to date is appended hereto as information.

Respectfully submitted on behalf of the sub-committee,

A. Ludlow Clayden,
Chairman.

APPENDIX

PROPOSED OXIDATION TEST FOR MINERAL OILS (SLIGH METHOD)

This method of measuring the resistance of mineral oils to oxidation was developed in the oil laboratory of the U. S. Bureau of Standards. It is the outcome of several years of experimentation with the object of developing an oxidation test which would yield consistent results, which could be precisely specified so that agreement between different laboratories would be possible, and which would not make extraordinary demands upon the operator's time or patience.

It has been taken for granted that the mass of residue precipitated from a petroleum naphtha solution of an oxidized oil is a comparative measure of the degree of oxidation of the oil. With this as a basis, various methods of subjecting the oils to definite oxidizing influences have been investigated with this method as the result.

1. The procedure for this method shall be as follows:

(*a*) Weigh into a clean standard oxidation flask[1] a sample of 10g. ± 0.1 g. of the oil. Displace the air in the flask by oxygen under atmospheric conditions (760 mm. of mercury and 25° C.) and clamp the slightly greased ground stopper carrying the connection plug into place.

NOTE.—This joint should be gas tight as leakage of oxygen during the test will, produce low results.

(*b*) Immerse the flask and sample vertically in a well-stirred oil bath, Fig. 2, maintained at 200° C. (392° F.) to a point about 1 in. above the body of the flask. Remove after 2½ hours at this temperature.

(*c*) When cool, dilute the oxidized oil to a total volume of 100 cc. with petroleum naphtha. Shake to dissolve the oxidized oil and allow to stand for one hour at a temperature of 25° C. with a variation of ±2.0° C.

NOTE.—The naphtha used should have an end point below 120° C. (248 F.) and should be free from unsaturated and cyclic compounds. The naphtha specified in the Tentative Method of Test for Precipitation Number of Lubricating Oils (D 91 – 21 T)[2] should be used as standard, though any suitable naphtha may be used for the comparative rating of a given series of oils. In general, the amount of precipitate obtained from a given sample of oxidized oil increases with the volatility of the naphtha used.

(*d*) Filter and weigh the precipitate. The weight of this precipitate expressed as a percentage of the weight of the sample of oil used and multiplied by 100 is the oxidation number of that sample. Thus, a precipitate of 0.0205 g. (20.5 mg.) from a 10.0 g. sample would be expressed as an oxidation number of 20.5.

---

[1] Standard oxidation flasks and oil pipettes as shown in Fig. 1 are manufactured in Pyrex glass and may be obtained through dealers in laboratory supplies.

[2] *Proceedings*, Am. Soc. Testing Mats., Vol. 21, p. 648 (1921); also 1926 Book of A.S.T.M. Tentative Standards, p. 457.

The above procedure is thought to be sufficient if followed precisely to ensure consistent results. However, the specific procedure followed in the oil laboratory of the U. S. Bureau of Standards is described in detail below as it may serve to call attention to some desirable precautions and conveniences.

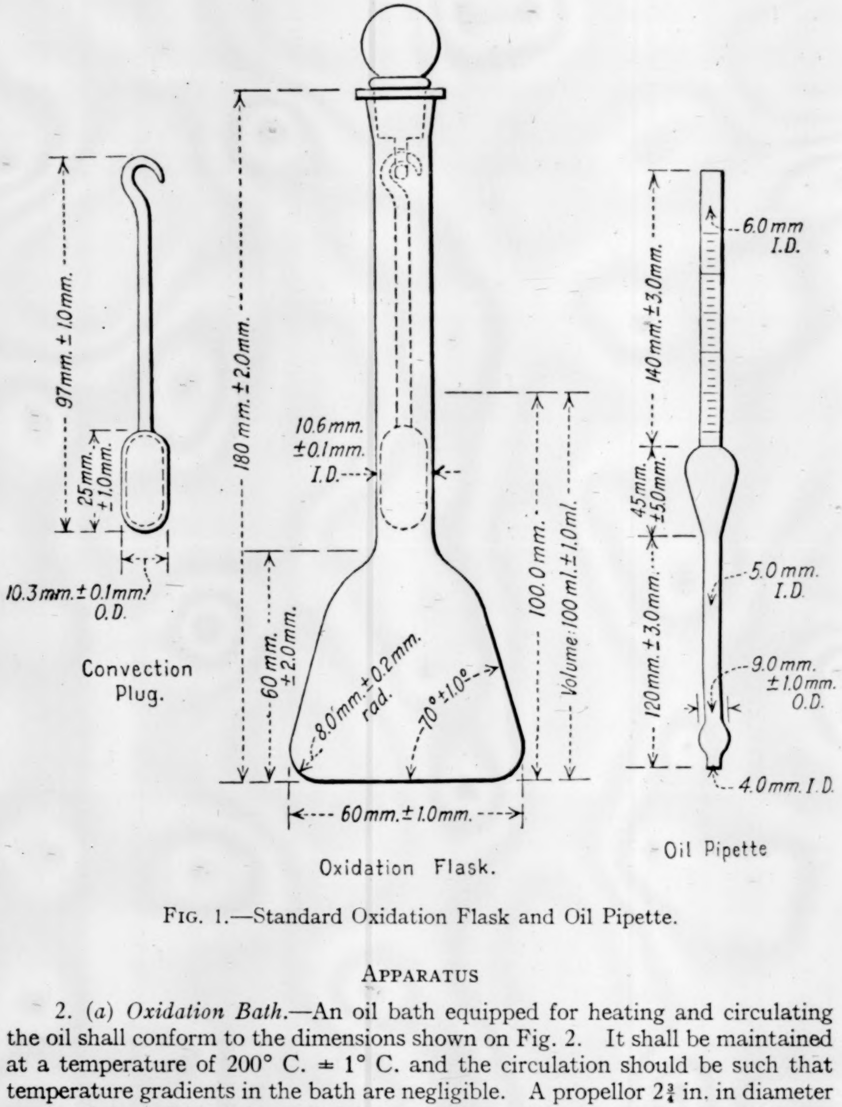
97 mm. ± 1.0 mm.
25 mm. ± 1.0 mm.
10.3 mm. ± 0.1 mm. O.D.
Convection Plug.
180 mm. ± 2.0 mm.
10.6 mm. ± 0.1 mm. I.D.
60 mm. ± 2.0 mm.
8.0 mm. ± 0.2 mm. rad.
70° ± 1.0°
100.0 mm.
Volume: 100 ml. ± 1.0 ml.
60 mm. ± 1.0 mm.
Oxidation Flask.
6.0 mm I.D.
140 mm. ± 3.0 mm.
45 mm. ± 5.0 mm.
5.0 mm. I.D.
120 mm. ± 3.0 mm.
9.0 mm. ± 1.0 mm. O.D.
4.0 mm. I.D.
Oil Pipette

FIG. 1.—Standard Oxidation Flask and Oil Pipette.

APPARATUS

2. (*a*) *Oxidation Bath.*—An oil bath equipped for heating and circulating the oil shall conform to the dimensions shown on Fig. 2. It shall be maintained at a temperature of 200° C. ± 1° C. and the circulation should be such that temperature gradients in the bath are negligible. A propellor $2\frac{3}{4}$ in. in diameter mounted in a 3-in. tube and driven at about 600 r.p.m. will give adequate circulation. The bath shall be of sufficient size to accommodate at least six oxidation flasks. A bath 8 in. deep having a capacity of about 3 gal. is suggested. If of a circular form the diameter would be 10 to 11 in. Clamps or supports

to hold the flasks in a vertical position shall be provided and a well-fitted cover should be used to reduce the rate of deterioration of the bath fluid and to protect the greased seals on the flasks from overheating. In *very warm* weather it may be necessary to direct a blast of air, as from an electric fan, across the top of the bath to keep these seals cool. Leakage of oxygen almost invariably results if the stop-cock grease becomes hot enough to flow.

(*b*) The oil used in the bath should, for safety, have a high flash point and should also have a high resistance to oxidation.

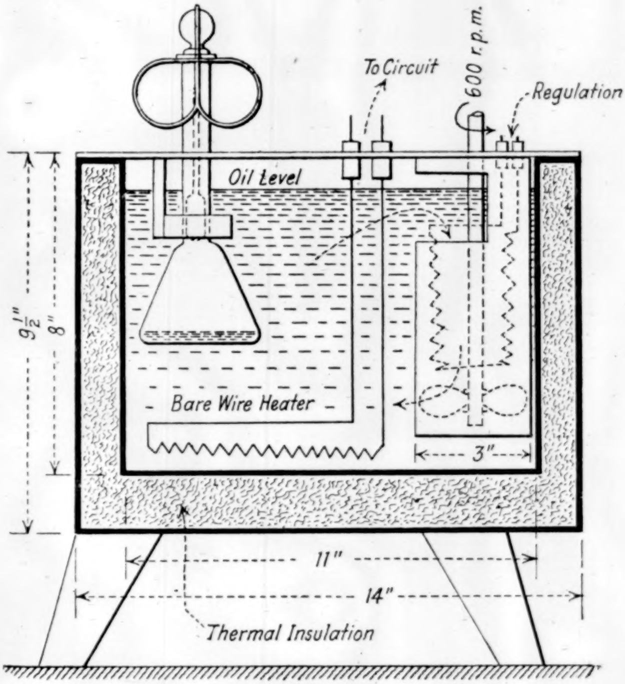

Fig. 2.—Oil Bath for Oxidation Test for Mineral Oils.

(*c*) A bath having the construction shown in Fig. 2 should require an input of from 200 to 300 watts to maintain a temperature of 200° C. Manual or automatic temperature control may be used as desired.

3. *Drying Oven.*—The drying oven shall be an air oven in which a temperature of about 105° C. (230° F.) is maintained.

4. *Balance.*—The analytical balance shall be sensitive to 0.0001 g. For rough weighing to 0.01 g. it is convenient to reduce the sensitivity and period by attaching a small (2 g.) weight on the pointer. A sensitivity of 1 division on the scale for 0.01 g. permits very rapid weighing of oil samples. The full sensitivity shall, of course, be used in obtaining the weight of precipitates.

5. (*a*) *Oxidation Flasks.*—The oxidation flasks shall be special long-necked Erlenmeyer flasks with ground-glass stoppers and convection plugs conforming to the dimensions shown on Fig. 1. The convection plugs shall be interchange-

able in the flasks and serve to render the temperature in the flask independent of the temperature of the room. Convection up and down the neck is also suppressed by their use.

(*b*) It is essential that the stoppers shall be a good fit in the neck. This may be tested by seating the stopper with a drop of naphtha on the grinding. Under this condition the stopper should seat firmly without shake which may be readily detected by the motion of the thin film of naphtha between the surfaces when a lateral force is applied to the top of the stopper. The stopper clamps (see Fig. 3) shall be bent to shape from phosphor-bronze spring wire 0.057 in. in diameter (No. 15 B. & S. gage). The half-rings which encircle the flask neck just below the bead shall be cushioned with a wrapping of thread or a short length of soft tubing such as rubber or varnished cambric to avoid localized pressure which might cause breakage of the flasks.

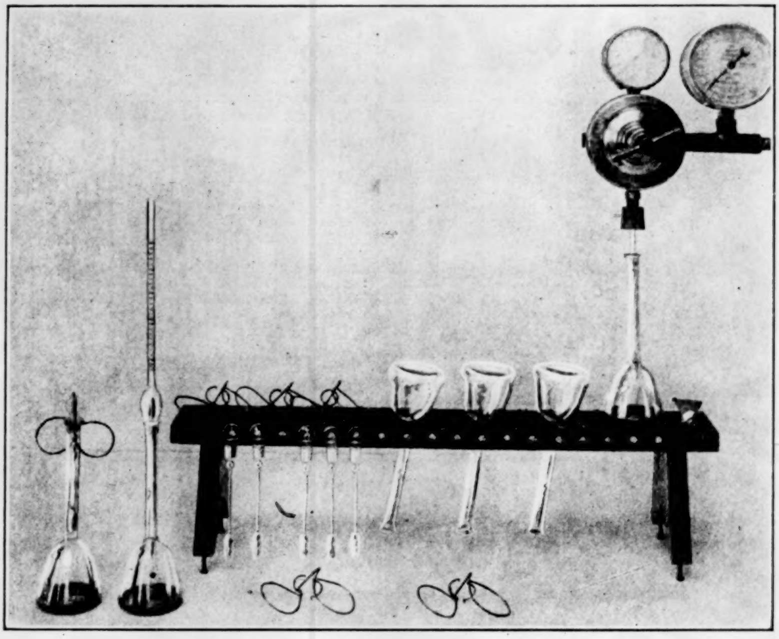

FIG. 3.—Oxidation Apparatus and Rack for Drying.

NOTE.—This cushioning material is not shown on the clamps in Fig. 3 but should be used. The clamps should exert a total force of about 2 lb. on the stoppers.

6. *Gooch Crucibles.*—Gooch crucibles of the ordinary variety, size No. 3. (25 cc.) of porcelain with perforated bottoms shall be used. These may be marked for identification (see Fig. 4) with chromium oxide and a small amount of borax made up to a creamy paste with water and burned in. The marking may be made on the crucible with a steel pen, allowed to dry in air, and burned-in at a temperature of about 1000° C. with a blow torch or in a furnace.

7. *Suction Flask and Accessories.*—Figure 4 shows a convenient filtration outfit. The suction flask, *A*, shall be connected to the suction system by a rubber tube to which a three-way valve, *V*, is connected by a glass T. This valve shall connect to a 300-cc. drexel-form gas wash bottle *B* as shown, which shall be filled with mercury to a depth of about 8 cm. The other valve con nection opens to the atmosphere.

8. *Oil Pipettes.*—The oil pipettes shall conform to the dimensions shown in Fig. 1 and shall be used in weighing the samples of oil into the oxidation flasks to permit easy adjustment to the desired weight and to prevent soiling of the sides and neck of the flask.

9. *Erlenmeyer Flasks.*—Erlenmeyer flasks from ordinary stock should be roughly calibrated and marked for a volume of 100 cc.

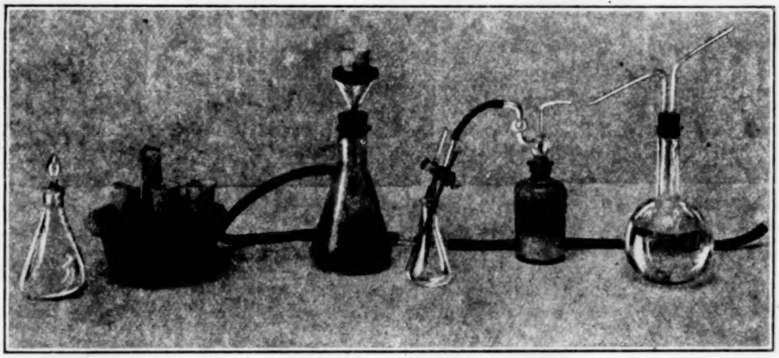

FIG. 4.—Filtration Outfit.

MATERIALS

10. *Stop-Cock Grease.*—Stop-cock grease shall be of medium or hard grade as required to maintain the seal under the operating conditions. A grease made of 72 per cent of petrolatum, 16 per cent of rubber (pure gum), and 12 per cent of paraffin cooked at 200° C. has proven satisfactory.

11. *Solution for Cleaning Flasks.*—A saturated solution of sodium hydroxide in water to which 50 per cent by volume of denatured alcohol (ethyl + 10 per cent methyl) has been added shall be used for cleaning the flasks.

12. *Strong sulfuric acid for rinsing flasks.*

13. *Distilled water.*

14. *Petroleum naphtha.*

15. *Asbestos Suspension.*—An asbestos solution for making up the filters shall consist of a suspension of about 6 g. of finely divided asbestos fiber in one liter of distilled water. The suspension shall be made up by shaking the asbestos in water until the bundles of fiber are completely disintegrated. The fine suspension should then be decanted from the small amount of coarse fiber which settles rapidly to the bottom of the vessel. Acid-washed short fiber is suitable for this work and disintegrates into a fine suspension more readily than does the more expensive long fiber material.

PROCEDURE

16. (*a*) *Weighing of Oil Sample.*—The weight of the clean empty flask shall be obtained. A card bearing these weights and the approximate weights of the crucibles posted near the balance will prove a great convenience. Approximately 12 cc. of oil shall be drawn into the oil pipette, the tip of the pipette wiped and the oil transferred to the weighed flask, allowing the oil to drain to a definite point, say till 10 oil drops have been formed. A 10-g. weight shall be placed on the weight pan and a rough balance obtained. The weight of sample is, say, 9.82 g. The pipette shall be replaced in the flask and 3 drops (about 0.05 g. per drop) allowed to drain in, an exact balance now should show 9.95 g., which is within the specified limits (10 g. ± 0.1 g.).

(*b*) *Filling with Oxygen.*—The stoppers of the flasks shall now be slightly greased and the convection plugs attached. A flask shall be brought up over a vertical glass tube through which oxygen (commercial purity as supplied in drums) is issuing downwards at the rate of about 2 liters per minute. The flask shall be held in this position for about 30 seconds (see Fig. 3), and then removed and the stopper carrying the connection plug quickly put in place, seated and clamped.

(*c*) The increase in pressure upon heating is largely due to the expansion of the oxygen, as the vapor pressure of lubricating oils is low even at 200° C., so that with the small necks used a light clamp exerting a total pressure of about 2 lb. should be sufficient.

(*d*) The flasks shall now be placed in their clips in the bath, which has already been brought to a temperature of 200° C. The level of the bath liquid should be about 1 in. above the body of the flasks and sufficient space should be left between the flasks and the bottom and sides of the bath for free oil circulation.

(*e*) After 2½ hours at 200° C. the flasks shall be removed and allowed to cool, and the bath oil washed off in a vessel of gasoline or gasoline-benzol mixture kept for this purpose. The flasks shall then be opened and about 50 cc. of petroleum naphtha added to dissolve the oxidized oil. This solution shall be transferred to a 100-cc. short-necked Erlenmeyer flask, the rinsing from the oxidation flask added, and the solution made up to a total volume of 100 cc. The precipitation flasks shall be corked and set aside to precipitate at a temperature of about 25° C. for 1 hour.

NOTE.—This precipitation is an equilibrium process and the final state depends upon the temperature as well as upon the nature of the solution. The temperature coefficient of solubility of these oil naphtha solutions is such that, in general, the mass of precipitate is increased by about 1 mg. for each 5° C. decrease in the temperature of precipitation. Except in precision work, it is not ordinarily necessary to take special precautions to ensure the proper precipitation temperature; however, it is customary in the laboratory of the U. S. Bureau of Standards to set the precipitation flasks in a large vessel of water at room temperature and to observe and record the temperature of this water at the time filtration is made. This permits an approximate correction to 25° C. and guards against rapid changes in temperature.

After the oxidized oil is transferred to the precipitation flasks the oxidation flasks shall be thoroughly cleaned as described in Section 19.

17. (*a*) *Preparation of Filters.*—The desired number of Gooch crucibles shall be set on a rack above a pan or drain, Fig. 4, and into each shall be poured about 20 cc. of the asbestos water suspension. This shall be allowed to drain

for a few minutes to permit the formation of a thin mat on the bottom of the Gooch crucible and each crucible then sucked dry over the suction flask. The suction valve may be opened wide and the by-pass valve *V* closed to give rapid action. The filter may be washed through with denatured alcohol (90 per cent ethyl + 10 per cent methyl) to hasten the drying, if desired.

(*b*) The filters shall then be heated in the drying oven for from 30 minutes to 1 hour as required and allowed to cool in a dessicator, from which they are taken to be weighed when needed.

NOTE.—If the crucibles are slightly warm or if they have become electrified, due to wiping before weighing, erratic weighings will result. No difficulty will be encountered due to atmospheric moisture as neither the filter nor the filtrate takes up moisture readily. Weighings of filters should be taken to the nearest 0.0001 g.

18. (*a*) *Filtration.*—The weighed filter shall be placed on the suction flask, well seated, and the suction valve set to give a slight bubbling through the mercury by-pass, *B*, Fig. 4, which should be set to release at a suction of about 8 cm. of mercury.

(*b*) The clear solution above the precipitate shall now be poured on the filter. A small metal spreader may be used if the filter pad shows a tendency to wash aside. When the precipitate begins to appear the pouring shall be stopped, the neck of the precipitation flask rinsed into the filter with a stream of petroleum naphtha from the wash bottle.

(*c*) The oil on the sides of the filter shall now be washed down with a stream of petroleum naphtha and the precipitate carefully poured on. Care should be taken to rinse all precipitate out of the precipitation flasks using a stiff bristle brush to loosen up adherent precipitate. Finally, the precipitate and the filter shall be thoroughly washed with naphtha to remove traces of oil, sucked dry and placed in the drying oven for 15 to 30 minutes, and when dry removed to cool in the desiccator and the second weighing taken.

19. (*a*) *Cleaning Flasks.*—The oxidation flasks after use shall be filled with a solution of alcoholic caustic-soda and allowed to stand over night or heated for 30 minutes in a vessel of water at about 50° C. and allowed to stand for several hours.

(*b*) The solution shall then be poured back into its container, the flasks shaken out with clean, coarse washing sand to remove the deposit which the cleaning solution has loosened but not dissolved. After rinsing with tap water, sulfuric acid shall be used to neutralize traces of soda which are active in promoting oxidation. The acid shall then be thoroughly rinsed out with tap water and after a final rinsing with distilled water the flasks set slantwise in a rack, not on pegs, to drain and dry; see Fig. 3.

(*c*) These narrow-necked flasks dry slowly but the process may be hastened, if desired, by heating in the drying oven and inverting the warm flask over a tube through which air is drawn by suction.

(*d*) This thorough cleaning is essential and shall be performed each time a test is run as traces of oxidized oil remaining in the flask may produce erroneous results in the succeeding test.

The precipitation flasks often show a slight brownish stain which is partially removed upon rinsing into the filter. The mass of this adherent film is negligible as compared to the total mass of the residue.

(*b*) Precipitation flasks shall be cleaned by rinsing with benzol or carbon tetrachloride followed by petroleum naphtha.

Gooch Crucibles.—After the final weighings the filter pads shall be taken out and any stain wiped off with a cloth moistened in benzol or carbon tetrachloride. The crucibles shall be rinsed with petroleum naphtha and may then be made up for the next test.

SOURCES OF ERROR

19. *Oxygen Loss.*—A large part of the troubles reported from a number of laboratories regarding this test seem to be attributable to loss of oxygen from the flask during the test. This may be due to a poor fit of the stopper in the neck or the overheating of this point due to inadequate insulation of the top of the oxidation bath.

20. *Breakage of Flask*—Some breakages of the flask at the grinding have been reported. These may be due to poor fit of the stopper, grit on the grinding or more probably to localized pressure of the clamp on the neck or bead.

Erratic results may also be due to imperfect cleaning of the flasks or accidental contamination after cleaning.

DISCUSSION

This oxidation test was designed primarily for the examination of internal-combustion engine lubricants and the conditions of test were chosen with special reference to simplification, reproducibility and acceleration of the tests. Thus, 200° C. seems to be the highest temperature at which reproducible results may be readily obtained, though a lower temperature may be found more suitable for certain classes of oils.

The use of the mass of asphaltene precipitated from a definite solution of the oxidized oil in petroleum naphtha as a measure of the deterioration of the sample under test seems justified because this precipitate is the product which is largely responsible for the formation of troublesome deposits and "sludges" in service. In addition, the evaluation of this precipitate is fairly simple and has long been in use in oil laboratories.

However, this precipitate is only one of the products of oxidation and it may well be that other products in addition, acidity for instance, may be found to have great influence upon the utility of the oil for certain classes of service.

The test, however, appears to have certain general advantages regardless of the specific conditions of test and the method of evaluation of results which may be found to be useful in particular cases. These advantages may be summed up as follows:

The conditions of test are definitely reproducible and may be varied independently thus permitting a study of the effects of each factor.

The effects of catalyzers such as metallic oxides or the effects of the oxidation products upon materials with which the oil is in contact in service may be investigated.

The reaction takes place in a closed system and so effects of different atmospheres, air, ammonia and the like, upon the reaction may be noted. Further, all of the reaction products are available for evaluation and study and it may thus be possible to work out a complete reaction balance for a given set of conditions. It has been noted that in oxidation substances are formed which have higher molecular weights than the original oil; acids, carbon dioxide and water vapor are also formed.

The quantitative evaluation of these products for particular oils should yield information regarding the effects of methods of refining and treatment upon the stability of the oil.

REPORT OF SUB-COMMITTEE XI ON TURBINE OILS

This report covers the results from tests on two samples of turbine oil sent out under designations 26 – 1 and 26 – 3, in accordance with the recommendation contained in the 1926 report of the sub-committee as follows:

1. A.S.T.M. steam emulsion tests (Method D 157 – 23 T) and Herschel demulsibility tests, given in Table I.
2. Funk Sludging Machine tests, given in Table II.
3. Physical tests of samples 26–1 and 26–3, given in Table III.
4. A few Sligh oxidation tests values, given in Table IV.

The results of the A.S.T.M. steam emulsion tests and the Herschel demulsibility tests indicate that more uniform results are obtained, by one person making repeated check runs and by different laboratories, with the steam emulsion test than with the demulsibility test. Due to the form of the directions for the demulsibility test, a very good oil settling out in any time less than one minute, even though the actual time for settling might vary from 20 seconds to 60 seconds, would be reported as settling in one minute (the time prescribed for taking the first observation). All the various reports would then be reported as

$$\frac{27}{1/60} = 1620$$

as the rate of settling in cubic centimeters per hour, even though actually varying more than one-half minute from each other and having actual deviations up to 50 per cent.

The following tabulation of the results obtained by Laboratory M is typical of the individual results of various laboratories. It shows the greater degree of uniformity obtained with the A.S.T.M. method than with the demulsibility method:

	Sample 26–1		Sample 26–3	
	A.S.T.M. Steam Emulsion Test	Herschel Demulsibility	A.S.T.M. Steam Emulsion Test	Herschel Demulsibility
Run No. 1	49	900	92	1320
Run No. 2	49	720	91	1440
Run No. 3	50	1080	91	1500
Average	49	900	91	1420

Table I shows a comparison of the results of different laboratories.

The Funk Sludging Machine tests are shown in Table II. Unfortunately, only three laboratories have reported to date on these tests. Therefore, since so few results have been obtained no conclusions should yet be drawn from them.

A few laboratories reported the results of the Sligh oxidation test and they are included in Table IV.

It should be borne in mind that the Funk and Sligh tests were intended to follow a *progressive* change in an oil, while the Steam Emulsion and the Herschel tests determine a condition at the moment of making the test.

Conclusions:

1. From the immense amount of work that has been done by Sub-Committee XI in cooperation with the representatives of the largest users of turbine oils, it is found that more concordant results can be obtained by a particular observer and by different laboratories with the A.S.T.M. steam emulsion test than with the Herschel demulsibility test. The steam emulsion test is much easier to run than the Herschel demulsibility test.

TABLE I.—COMPARATIVE RESULTS OF A.S.T.M. STEAM EMULSION TEST AND HERSCHEL DEMULSIBILITY TEST.

Laboratory	Sample 26-1		Sample 26-3	
	A.S.T.M. Steam Emulsion, seconds, Average	Herschel Demulsibility Values, cc. per hour, 130° F., Average	A.S.T.M. Steam Emulsion, seconds, Average	Herschel Demulsibility Values, cc. per hour, 130° F., Average
A	30	1620	60	1500
B	33	1200	60	1080
C	..	....	..	....
D	53	1620	65	1480
E	36	1620	36	1620
F	34	1095	71	930
G	30	1620	66	150
H	30	1380	61	1380
I	50	1620	74	600
J	..	....	55	1200
K	47	1620	74	1540
L	3	1450	31.1	1533
M	49	900	91	1420
N	32	1620	103	930
Average	36	1447	65	1182
Sum of Deviations	..	....	−87 + 89	−2220 + 2217
			176	4437
			±13.5, or 21 per cent	±341, or 29 per cent

2. While neither absolutely checks actual operations, the steam emulsion test comes nearer to checking actual operations than the demulsibility test.

3. A very large amount of valuable data has been collected, covering the results of the steam emulsion test on a very wide range of turbine oils of different qualities. In analyzing these data, it is seen that oils of one quality fall within the limits of certain S. E. numbers, while oils of better or inferior quality fall within other

limits. Therefore, it is concluded that the sub-committee has sufficient data on hand to indicate limits for S. E. numbers which will classify turbine oils.

4. The A.S.T.M. Tentative Method of Test for Steam Emulsion of Lubricating Oils (D 157 – 23 T) has not only been widely used for several years but has given satisfaction in many laboratories. In addition, a number of large users of turbine oils have included this test in their specifications.

TABLE II.—RESULTS OF FUNK SLUDGING MACHINE TESTS AFTER RUNNING FIFTY HOURS WITH ADDITION OF WATER.

All Values Given are in Terms of Per Cent.

	SLUDGE AND EMULSION		SLUDGE		EMULSION	
	SAMPLE 26–1	SAMPLE 26–3	SAMPLE 26–1	SAMPLE 26–3	SAMPLE 26–1	SAMPLE 26–3
Laboratory I.......	1.00	2.5	0.05	0.30	0.95	2.20
Laboratory J.......	..	5	..	0.40	..	4.50
Laboratory K......	2	Trace	0.10	0.05	1.9	Trace

TABLE III.—PHYSICAL TESTS ON SAMPLES.

	SAMPLE 26–1	SAMPLE 26–3
Gravity, deg. A. P. I..............................	24.6	21.8
Flash Point, deg. Fahr..............................	320	325
Fire Point, deg. Fahr..............................	365	370
Viscosity at 100° F., seconds..............................	147	146
Color..............................	1 –	2 –
Pour Point, deg. Fahr..............................	–0	–0
Neutralization Number..............................	0.01	0
Ash, per cent..............................	0	..
Sulfur, per cent..............................	0.10	0.58

TABLE IV.—SLIGH OXIDATION TESTS.

Values Reported as Oxidation Numbers.

	SAMPLE 26–1	SAMPLE 26–3
Laboratory A..............................	9.15	8.2
Laboratory D..............................	11.2	24.3
Laboratory I..............................	..	14.8
Laboratory J..............................	..	24.58
Laboratory K..............................	15	44

Recommendations:

In reference to the above conclusions, the sub-committee recommends the following:

1. That the A.S.T.M. Tentative Method of Test for Steam Emulsion of Lubricating Oils (D 157 - 23 T) with slight changes, incorporated in the body of the report of Committee D-2, be made a standard of the Society.

2. That Sub-Committee XI make a study of the large amount of data which the committee has obtained in the interpretation of S. E. numbers and their indication as to proposed limits.

Thanks should be given to Mr. Funk for his splendid cooperation and his assistance in getting the help and interest of some of the large users of turbine oils in cooperating with the committee.

Respectfully submitted on behalf of the sub-committee,

JAMES T-B. BOWLES,
Chairman.

REPORT OF SUB-COMMITTEE XXIII ON CARBON RESIDUE

Because there has always been more or less lack of concordance between different laboratories in checking the amounts of carbon residue found in applying the Conradson method, and as it was believed that these differences might be due to the interpretation of the instructions, the sub-committee was asked to specify in greater detail the apparatus to be employed and to so state the various steps that there should be no mistaking the intent of the procedure. This has been done and the proposed revision is appended hereto.[1]

The data obtained by the sub-committee both under the chairmanship of Mr. Lane and during the past year demonstrate the importance, in order to obtain concordant results, of applying heat in a definite manner and for a definite time; and after considerable experimental work, the procedure described in the revised method was developed.

The data from four sets of tests are incorporated below to show what may be expected from the use of the revised method:

Test No. 1.—One sample tested by six laboratories gave the following results:

LABORATORY	CARBON RESIDUE, PER CENT			
	INDIVIDUAL RESULTS			AVERAGE
No. 1	1.22	1.30	1.33	1.307
No. 2	1.22	1.27	1.39	1.29
No. 3	1.29	1.31	....	1.30
No. 4	1.29	1.37	....	1.33
No. 5	1.37	1.38	....	1.375
No. 6	1.75	1.85	....	1.80

Test No. 2.—Four samples of widely different carbon residues run by five laboratories gave the results appearing in Table I. The only serious deviation under the new strict control is on the oils having the highest residue.

Test No. 3.—One oil was run by the same operator to show the effect on the quantity of residue of the height of burning vapors as controlled by the time of burning, with the results shown in Table II.

Test No. 4.—Tests run at various burning periods gave the results shown in Table III.

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[1] See p. 915.—Ed.

TABLE I.—RESULTS OF TEST NO. 2, ON OILS OF DIFFERENT CARBON RESIDUES.

Laboratory	Pre-ignition Period, minutes	Burning Period, minutes	Final Period, minutes	Total Time, minutes	Carbon Residue, per cent	Average, per cent
SAMPLE No. 1						
No. 1	9.5	11.5	7.0	28.0	1.19	
	10.5	11.0	7.0	28.5	1.18	
	10.5	11.0	7.0	28.5	1.17	1.18
No. 2	10.0	11.0	7.0	28.0	1.18	
	12.0	12.0	7.0	31.0	1.20	
	10.0	11.0	7.0	28.0	1.14	1.17
No. 3	12.0	13.0	7.0	32.0	1.241	
	12.0	13.0	7.0	32.0	1.243	1.242
No. 4	8.5	15.0	7.0	30.5	1.34	
	....	....	...	....	1.32	
	7.25	16.75	7.0	31.0	1.34	
	....	....	...	....	1.29	1.32
No. 5	9.5	13.5	7.0	30.0	1.33	
	10.0	12.75	7.0	29.75	1.30	1.315
SAMPLE No. 2						
No. 1	9.5	13.0	7.0	29.5	0.64	
	10.0	14.0	7.0	31.0	0.61	
	11.0	12.5	7.0	30.5	0.60	0.62
No. 2	12.0	12.0	7.0	31.0	0.63	
	10.0	11.0	7.0	28.0	0.64	
	12.0	12.0	7.0	31.0	0.61	0.63
No. 3	9.0	15.5	7.0	31.5	0.621	
	9.5	15.5	7.0	32.0	0.645	0.633
No. 4	8.0	19.0	7.0	34.0	0.677	
	....	....	...	....	0.684	
	7.5	17.25	7.0	31.75	0.640	
	....	....	...	....	0.531	0.633
No. 5	9.0	14.0	7.0	30.0	0.657	
	9.75	15.0	7.0	31.75	0.635	0.646
SAMPLE No. 3						
No. 1	10.5	14.0	7.0	31.5	0.36	
	10.5	13.5	7.0	31.0	0.35	
	9.0	10.0	7.0	26.0	0.35	0.35
No. 2	10.0	11.0	7.0	28.0	0.37	
	12.0	11.0	7.0	30.0	0.34	
	11.0	12.0	7.0	30.0	0.37	0.36
No. 3	8.5	15.5	7.0	31.0	0.364	
	9.5	15.5	7.0	32.0	0.385	0.375
No. 4	9.0	15.0	7.0	31.0	0.354	
	....	....	...	....	0.395	
	9.5	11.0	7.0	27.5	0.343	
	....	....	...	....	0.358	0.363
No. 5	9.25	12.75	7.0	28.75	0.394	
	10.25	14.5	7.0	31.75	0.375	0.385

TABLE I.—*Continued.*

Laboratory	Pre-ignition Period, minutes	Burning Period, minutes	Final Period, minutes	Total Time, minutes	Carbon Residue, per cent	Average, per cent
SAMPLE NO. 4						
No. 1	10.5	12.5	7.0	30.0	0.13	
	10.0	10.5	7.0	27.5	0.13	
	10.0	11.0	7.0	28.0	0.13	0.13
No. 2	11.0	11.0	7.0	29.0	0.16	
	9.0	12.0	7.0	28.0	0.16	
	11.0	12.0	7.0	30.0	0.14	0.15
No. 3	10.5	15.0	7.0	32.0	0.157	
	10.5	14.5	7.0	32.0	0.159	0.158
No. 4	9.5	15.5	7.0	32.0	0.176	
	....	....	...	....	0.160	
	8.75	13.0	7.0	28.75	0.156	
	....	....	...	....	0.145	0.159
No. 5	9.0	14.0	7.0	30.0	0.168	
	9.25	15.5	7.0	31.75	0.162	0.165

TABLE II.

	Pre-ignition Period, minutes	Burning Period, minutes	Final Period, minutes	Total Time, minutes	Carbon Residue, per cent	Remarks
Run No. 1	10.5	10.0	7.0	27.5	0.62	Burned fast. Flame always at height of bridge.
Run No. 2	9.0	10.0	7.0	26.0	0.61	
Run No. 3	10.0	15.5	7.0	32.5	0.73	Burned slow. Flame at top of chimney.
Run No. 4	10.0	13.5	7.0	30.5	0.73	
Run No. 5	9.5	12.5	7.0	29.0	0.66	
Run No. 6	11.0	11.0	7.0	29.0	0.63	Burned medium. Flame between bridge and chimney, also with 2 beads in crucible.
Run No. 7	11.0	12.0	7.0	30.0	0.66	

TABLE III.

	Pre-ignition Period, minutes	Burning Period, minutes	Final Period, minutes	Total Time, minutes	Carbon Residue, per cent	Remarks
Run No. 1	10.5	18.5	7.0	36.0	1.95	Slow
Run No. 2	10.0	16.0	7.0	33.0	1.88	Slow
Run No. 3	11.0	12.0	7.0	30.0	1.71	Medium
Run No. 4	9.0	10.0	7.0	26.0	1.63	Fast
Run No. 5	10.0	9.5	7.0	26.5	1.62	Fast

The flame went out on both the "slow" runs (Runs Nos. 1 and 2) and had to be relighted while the others continued burning. The same oil was run exactly as prescribed in the proposed revision and gave 1.62 and 1.67 per cent, checking very well both the "fast" and "medium" speeds.

This oil was reported by a commercial laboratory with five minutes final and 30 to 40 minutes total time as follows:

	CARBON RESIDUE, PER CENT
First operator	2.20
First operator	2.04
Second operator	2.15
Third operator	2.10
Third operator	2.09

These results agree closely among themselves, and fairly well with those obtained with the "slow" period reported above.

Respectfully submitted on behalf of the sub-committee,

FLORUS R. BAXTER,
Chairman.

REPORT OF SUB-COMMITTEE XXV ON CRANKCASE DILUTION

The sub-committee has been studying methods of measuring crankcase dilution with a view to obtaining a method which is suitable for ordinary routine work, and which can be expected to yield results correct to within 1 per cent of the percentage of diluent in the oil. That is, a percentage of dilution measured as 15 per cent is expected to be certainly not-less than 14 per cent nor more than 16 per cent. The committee is agreed that no simple method can be expected to yield correct results on oils in which the diluent is derived from a fuel having a distillation end point higher than about 450° F.

Work on the capillary funnel method has offered considerable promise, the principal difficulty being in the specification of the rate of distillation. If this rate is too slow, considerable error may be introduced due to cracking of the oil in the flask.

The immediate work of the sub-committee will consist in a further check on this method and a comparison of the results with those obtained by a method suggested by R. E. Wilson, which consists in distilling the charge to a vapor temperature of 475° F. in the same apparatus, cutting off the heat and allowing the condenser to drain before observing the volume distilled as the diluent in the charge.

Respectfully submitted on behalf of the sub-committee,

T. S. SLIGH, JR.,
Chairman.

REPORT OF SUB-COMMITTEE XXVII ON APPLICATION OF TESTS

The work of this sub-committee during the past year has been along three lines, as follows:

1. In the preparation of a statement dealing with the considerations involved in the preparation of specifications for domestic oil fuel and incorporating proposed forms of specifications for two grades of fuel for this use, appended hereto, as information.
2. In cooperation with the Fuel Test Code Committee of the American Society of Mechanical Engineers in preparing a test code for liquid fuels.
3. In the preparation of a report on the testing of petroleum products, as outlined in the 1926 report of the committee. On account of the other activities of the committee, it has not been possible to complete this report in time for publication at this time.

Respectfully submitted on behalf of the sub-committee,

CHAS. A. LUNN,
Chairman.

APPENDIX[1]

CONSIDERATIONS INVOLVED IN THE PREPARATION OF SPECIFICATIONS FOR DOMESTIC OIL FUEL

This statement has for its purpose a discussion of the considerations involved in the preparation of specifications for domestic oil fuel, or the so-called furnace oils. It deals primarily with the properties which are important but does not attempt to fix limits, for the reason that only the manufacturer of each household oil burner is in a position to say exactly what oil is best for his particular equipment. It is the opinion of the committee that in the past a number of tests which are unessential or undesirable have been included in specifications, and in the recommended forms of specifications which follow, only those tests which are justified from the standpoint of usage are included. Due to the rather wide variation in types of fuel for which household burners are designed, it has been considered necessary to outline specifications for two main classes of oils, designated "A" and "B." Class A oils include the distillates related to kerosine, and Class B oils include the light fuel oils. Forms of specifications for these two classes of oils are presented.

Oil Characteristics Which Should Be Covered In Specifications:

The following tests should be included in specifications for domestic oil fuel. In listing these tests the committee has included comments intended to guide those intrusted with the completion of the attached forms for use as purchase specifications.

1. *Flash.*—For Class A oils it is desirable to specify minimum and maximum flash points. The minimum flash point is necessary for compliance with legal requirements. Due to the very wide variation in the regulations of different states and municipalities, it is not possible for the committee to specify the instrument to be used in determining the minimum flash point. Accordingly, the instrument and minimum flash point, which are legal for the locality in which the oil is to be sold, should be ascertained by the user of these forms of specifications and be included in them. A maximum flash point is desirable in some instances to take care of the operating requirements of certain types of burner equipment. Since legal considerations do not enter here, the standard instrument and method of test given in the attached forms should be used. The maximum flash point should be above 150° F. in all cases, and for localities where the minimum flash is 150° F., closed cup, it should be above 165° F.

For Class B oils only a minimum flash point is considered necessary. A minimum of 150° F., closed cup, is believed to be adequate to cover all legal and underwriters' requirements.

2. *Water and Sediment.*—Class A oils should be substantially free from water and sediment.

Class B oils should be reasonably free from these substances, but should not be expected to be as clean as Class A oils.

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[1] The subject matter in this appendix has been prepared by Committee D-2 on Petroleum Products and Lubricants of the American Society for Testing Materials at the request of the American Oil Burner Association for assistance in the problem of developing adequate and reasonable specifications for domestic oil fuels. It has already been distributed widely, in mimeographed form, throughout the petroleum and oil burner industries, for suggestions and criticisms and now appears for the first time in printed form.

3. *Pour Test.*—If some indication of the solidification point of Class A oils is desired the Pour Test should be applied. This test is seldom necessary, but to cover special cases it may be used. A maximum of 0° F. will cover most requirements.

For Class B oils the Pour Test should also be applied, since it is essential that the consumer be protected against wax-bearing distillates. A maximum of 30° F. Pour will be adequate for general conditions.

4. *Distillation Range.*—A distillation requirement is necessary for Class A oils to limit deliveries to the type of oil desired, and to insure proper fluidity and volatility. Only the 10-per-cent and 90-per-cent points need be specified, the former to assure the proper amount of readily volatile material, and the latter to protect against excessive amounts of high-boiling constituents.

5. *Viscosity.*—For Class A oils no viscosity requirement is necessary, since the distillation range clause will insure proper fluidity.

For Class B oils a maximum value only should be set. A limit of 75 seconds at 100° F., Saybolt Universal, is suggested.

6. *Carbon Residue.*—When the distillation range clause for Class A oils is properly drawn, no Carbon Residue requirement is necessary.

For Class B oils, a Carbon Residue requirement is generally unnecessary, but it may be included where the oil is intended for use in types of burners which are sensitive to excessive amounts of this material.

Oil Characteristics Which Should Not Be Covered In Specifications:

The following tests are undesirable for inclusion in specifications for either Class A or Class B oils. It should be borne in mind that the prices under which they are sold are of the greatest importance both to the burner manufacturers and to the consumer, and that specifications containing burdensome and unnecessary requirements will result in an increased price or a refusal of the refiner to offer oil under such conditions.

1. *Gravity.*—The gravity of an oil is of value only as an indirect and frequently unreliable, indicator of other characteristics. These forms of specifications are so drawn as to make gravity requirements entirely unnecessary.

2. *Color and Odor.*—Color has no bearing on the quality of the oil for the purpose in question. While some refiners artificially color their oils for identification purposes, any attempt to write color requirements into specifications will react unfavorably on both the burner manufacturer and the consumer.

Oils of this class cannot be expected to be ordorless, and as odor cannot be specified in terms of any measurable standard, it should not be included.

3. *Calorific Value.*—While the calorific values of Class A and Class B oils are, of course, the reason for their use, there can be no valid comparison made between oil and coal in this respect. Oils are 100-per-cent combustible, and the calorific value of an oil of a given class is subject to but slight variation. A difference of 5° A.P.I. gravity will in general make a difference of not more than 2 per cent in B. t. u. per gallon.

4. *Sulfur.*—Oils of the classes under consideration vary somewhat in sulfur content, but they do not remotely approach the sulfur content of heavy industrial fuel oil. A sulfur requirement is unnecessary from the standpoint of the consumer, and the inclusion of such in specifications for Domestic Oil Fuel would have the inevitable tendency to limit the available supply and increase the price.

PROPOSED FORM OF SPECIFICATIONS FOR DOMESTIC OIL FUEL, CLASS "A"

1. *Scope.*—These specifications cover oils closely related to kerosine oil, and frequently referred to as kerosine distillates.

2. *Properties.*—The oil shall conform to the following requirements:

(*a*) Flash Point
Minimum (instrument, method and temperature as specified) . °F.
Maximum (Pensky-Martens Closed Tester)................ °F.
(*b*) Water and Sediment, maximum.........................per cent
(*c*) Pour Point, maximum................................ °F.
(*d*) Distillation Test:
When 10 per cent has been collected in the receiver the thermometer reading shall not exceed.......................... °F.
When 90 per cent has been collected in the receiver the thermometer reading shall not exceed.......................... °F.

3. *Methods of Testing.*—The properties enumerated in these specifications shall be determined in accordance with the following methods of test of the American Society for Testing Materials, except as specified in Paragraph (*a*).

(*a*) *Flash Point:*

Minimum.—The instrument and method for determining minimum flash point shall be that legal for the locality in which the oil is sold.

Maximum.—The maximum flash point shall be determined in accordance with the Standard Method of Test for Flash Point by Means of the Pensky-Martens Closed Tester (Serial Designation: D 93).[1]

(*b*) *Water and Sediment:* Standard Method of Test for Water and Sediment in Petroleum Products by Means of Centrifuge (Serial Designation: D 96).[1]

(*c*) *Pour Point:* Tentative Method of Test for Cloud and Pour Points of Petroleum Products (Serial Designation: D 97 - 27 T).[2]

(*d*) *Distillation Test:* Standard Method of Test for Distillation of Gasoline, Naphtha, Kerosine, and Similar Petroleum Products (Serial Designation: D 86).[1]

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[1] 1927 Book of A.S.T.M. Standards, Part II.

[2] See p. 919.

PROPOSED FORM OF SPECIFICATIONS FOR DOMESTIC OIL FUEL, CLASS "B"

1. *Scope.*—These specifications refer to oils generally known to the trade as light fuel oils, intended for general industrial consumption.

2. *Properties.*—The oil shall conform to the following requirements:

(*a*) Flash Point (Pensky-Martens Closed Tester) Minimum ...... °F.
(*b*) Water and Sediment, maximum .... per cent
(*c*) Pour Point, maximum .... °F.
(*d*) Viscosity, Saybolt Universal at 100° F. Maximum .... seconds
(*e*) Carbon Residue, maximum .... per cent

3. *Methods of Testing.*—The properties enumerated in these specifications shall be determined in accordance with the following methods of test of the American Society for Testing Materials:

(*a*) *Flash Point.*—Standard Method of Test for Flash Point by Means of the Pensky-Martens Closed Tester (Serial Designation: D 93).[1]
(*b*) *Water and Sediment.*—Standard Method of Test for Water and Sediment in Petroleum Products by Means of Centrifuge (Serial Designation: D 96).[1]
(*c*) *Pour Point.*—Tentative Method of Test for Cloud and Pour Points of Petroleum Products (Serial Designation: D 97 - 27 T).[2]
(*d*) *Viscosity.*—Standard Method of Test for Viscosity of Petroleum Products and Lubricants (Serial Designation: D 88).[1]
(*e*) *Carbon Residue.*—Tentative Method of Test for Carbon Residue of Petroleum Products (Serial Designation: D 189 - 27 T).[3]

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[1] 1927 Book of A.S.T.M. Standards, Part II.
[2] See p. 919.
[3] See p. 915.

REPORT OF COMMITTEE D-4
ON
ROAD AND PAVING MATERIALS

Committee D-4 has held three meetings during the past year. No new specifications or methods of test are offered this year, but a number of existing standard and tentative specifications and tests have been revised and five tentative specifications and five tentative methods are recommended for advancement to standard.

The committee wishes to record its approval of the proposed revision of the Standard Method of Test for Water in Petroleum Products and Other Bituminous Materials (D 95 – 24), which is being recommended this year by Committee D-2 on Petroleum Products and Lubricants.

TABLE I.—REQUIREMENTS FOR SIEVE OPENINGS AND WIRE DIAMETERS WITH PERMISSIBLE VARIATIONS.

Mesh Designation, U. S. Standard Sieve Series Number	Sieve Opening		Wire Diameter		Tolerance in Average Opening, per cent	Tolerance on Wire Diameter, per cent		Tolerance in Maximum Opening, per cent
	mm.	in.	mm.	in.		Under	Over	
10	2.00	0.0787	0.76	0.0299	±3	15	30	10
20	0.84	0.0331	0.42	0.0165	±5	15	30	25
30	0.59	0.0232	0.33	0.0130	±5	15	30	25
40	0.42	0.0165	0.25	0.0098	±5	15	30	25
50	0.297	0.0117	0.188	0.0074	±6	15	35	40
80	0.177	0.0070	0.119	0.0047	±6	15	35	40
100	0.149	0.0059	0.102	0.0040	±6	15	35	40
200	0.074	0.0029	0.053	0.0021	±8	15	35	60

PROPOSED REVISION OF EXISTING STANDARD SPECIFICATIONS AND METHOD OF TEST

NO. 1. *Standard Method of Mechanical Analysis of Sand or Other Fine Highway Material Except Fine Aggregate Used in Cement Concrete (D 7 – 18).*[1]—In order to harmonize this method with the Standard Specifications for Sieves for Testing Purposes (E 11 – 26) the committee recommends that Table I of this method be revised to read as in the accompanying Table I, changing the heading of the first column to read: "Mesh Designation, *U. S. Standard Sieve Series Number.*"

Add a footnote to read as follows:

"The dimensions and tolerances for these sieves conform with the Standard Specifications for Sieves for Testing Purposes (Serial Designation: E 11) of the American Society for Testing Materials."

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[1] 1924 Book of A.S.T.M. Standards.

It is recommended that this revision be incorporated in the present standard method without publication as tentative. The commitee accordingly asks for the necessary nine-tenths vote for adoption of this revision as standard immediately.

No. 2. *Standard Method of Test for Loss on Heating of Oil and Asphaltic Compounds (D 6 - 20).*[1]—It is recommended that a footnote, referring to the title of the standard, be added, to read as follows:

> "The committee calls attention to the fact that the question of size of oven is now under consideration and that a possible revision of this standard may be expected."

Committee D-15 on Thermometers has called attention to the fact that the thermometer requirements appearing in this method are not in standard form and has prepared a new set of requirements which have been approved by Committee D-4. Adoption of the new thermometer requirements will not in any way change the test and the committee accordingly recommends that the following requirements be substituted for the existing requirements in Section 3:

The thermometer shall conform to the following requirements:

TYPE: Etched stem, glass.

LIQUID: Mercury.

RANGE AND SUBDIVISION: 155 to 170° C. in 0.5° C.

TOTAL LENGTH: 150 to 154 mm. (5.90 to 6.06 in.).

STEM: Plain front, enamel back, suitable thermometer tubing. Diameter, 6.0 to 7.0 mm. (0.24 to 0.28 in.).

BULB: Corning normal or equally suitable thermometric glass. Length, 10 to 15 mm. (0.39 to 0.59 in.) Diameter, 5.0 to 6.0 mm. (0.196 to 0.236 in.).

DISTANCE TO 0° C. LINE FROM BOTTOM OF BULB: 33 to 38 mm. (1.30 to 1.49 in.).

DISTANCE TO 155° C. LINE FROM BOTTOM OF BULB: 70 to 80 mm. (2.75 to 3.15 in.).

DISTANCE to 170° C. LINE FROM TOP OF THERMOMETER: 20 to 30 mm. (0.79 to 1.18 in.).

CONTRACTION CHAMBER: To be long narrow type, top to be not more than 65 mm. (2.56 in.) above bottom of the bulb.

EXPANSION CHAMBER: To permit heating the thermometer at least 25° C. above the highest temperature on the scale.

FILLING ABOVE MERCURY: Nitrogen gas.

TOP FINISH: Glass ring.

GRADUATION: All lines and figures clear cut and distinct. Each whole degree centigrade line to be longer than the remaining lines. Graduations are to be numbered at 0, 155, 163 and 170° C.

IMMERSION: Total.

SPECIAL MARKING: "A.S.T.M. Loss on Heat," a serial number and the manufacturer's name or trade mark shall be etched on the stem.

SCALE ERROR: The error at any point of the scale, when the thermometer is standardized as provided below shall not exceed 0.5° C.

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[1] 1924 Book of A.S.T.M. Standards.

STANDARDIZATION: The thermometer shall be standardized at three points including 163° C. for total immersion.

CASE: The thermometer shall be supplied in a suitable case on which shall appear the marking: "A.S.T.M. Loss on Heat, 155 to 170° C."

NOTE.—For the purpose of interpreting these specifications the following definitions apply:

The total length is the over-all length of the finished instrument.

The diameter is that measured with a ring gage.

The length of the bulb is the distance from the bottom of the bulb to the beginning of the enamel backing.

The top of the thermometer is the top of the finished instrument.

It is recommended that this revision be incorporated in the present standard method without publication as tentative. The committee accordingly asks for the necessary nine-tenths vote for adoption of this revision as standard immediately.

PROPOSED REVISIONS OF TENTATIVE SPECIFICATIONS AND METHODS OF TEST

No. 1. *Tentative Specifications for High-Carbon Tar for Surface Treatment, Hot Application (D 108 - 23 T)*[1] *and Tentative Specifications for High-Carbon Tar Cement (D 110 - 25 T)*.[2]—In order to meet criticisms which have been received and to make these specifications conform more closely to customary practice the following revisions are recommended in both specifications:

Section 1(d).—Change to read as follows by the addition of the italicized figures and the omission of the words and figures in brackets:

> "Specific gravity at [25° C. (77° F.)] *38° C. (100.4° F.)* of total distillate to 300° C. (572° F.) .... not less than [1.03] *1.02*."

Methods of Testing.—In the section on methods of testing, Sections 2 and 3, respectively, make the reference to the distillation test refer to the new Tentative Method of Test for Distillation of Bituminous Materials Suitable for Road Treatment (D 20 - 26 T) instead of the Standard Method of Test which later in this report is recommended for withdrawal. Rearrange and letter the test references to correspond with test requirements under the section on "Properties."

Footnote 2.—Delete footnote 2 to the requirements reading as follows:

> "All tests shall be made on the sample as received, including the distillation test, and the results reported on a dry basis."

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 23, Part I, p. 739 (1923); also 1926 Book of A.S.T.M. Tentative Standards, p. 549.

[2] *Proceedings*, Am. Soc. Testing Mats., Vol. 25, Part I, p. 740 (1925); also 1926 Book of A.S.T.M. Tentative Standards, p. 553.

It is recommended that these specifications as revised be continued as tentative.

No. 2. *Tentative Specifications for Coal-Tar Pitch for Stone Block Filler (D 112 - 23 T).*[1]—For reasons mentioned in connection with the preceding specifications the same revisions are recommended in connection with Section 1(*d*), Methods of Testing, and Footnote 2 of these specifications. In addition the following revision is recommended:

Section 1(c).—Change to read as follows by the addition of the italicized figures and the omission of those in brackets:

> "Distillation test:
> Total distillate, by weight, 0 to 300° C.
> (32 to 572° F.)............not more than [10.00] *14.00* per cent.
> Residue, by weight............not less than [90.00] *86.00* per cent."

It is recommended that these specifications as revised be continued as tentative.

No. 3. *Tentative Specifications for High-Carbon Tar for Surface Treatment, Cold Application (D 104 - 23 T);*[1] *for Low-Carbon Tar for Surface Treatment, Cold Application (D 105 - 23 T);*[1] *for High-Carbon Tar Cement for Use Cold in Repair Work (Cut-Back Product) (D 106 - 25 T);*[2] *for Low-Carbon Tar Cement for Use Cold in Repair Work (Cut-Back Product) (D 107 - 23 T);*[1] *for Low-Carbon Tar for Surface Treatment, Hot Application (D 109 - 23 T),*[1] *for Low-Carbon Tar Cement (D 111 - 23 T).*[1]—To harmonize these specifications with the other specifications for tar, it is recommended that the same change in reference to distillation test be made in Methods of Testing and that Footnote 2 to the requirements, reading as follows, be deleted:

> "All tests shall be made on the sample as received, including the distillation test, and the results reported on a dry basis."

It is recommended that these specifications as revised be continued as tentative.

No. 4. *Tentative Method of Test for Distillation of Bituminous Materials Suitable for Road Treatment (D 20 - 26 T).*[3]—To meet criticisms which have been received and to make certain requirements more specific the following revisions are recommended:

Figure 2.—Replace the present figure showing a cubical shield

with a figure conforming to the accompanying Fig. 1, showing a cylindrical shield.

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[1] *Proceedings,* Am. Soc. Testing Mats., Vol. 23, Part I, pp. 747, 731, 733, 737, 741 and 745(1923); also 1926 Book of A.S.T.M. Tentative Standards, pp. 557, 541, 543, 547, 551 and 555.

[2] *Proceedings,* Am. Soc. Testing Mats., Vol. 25, Part I, p. 738 (1925); also 1926 Book of A.S.T.M. Tentative Standards, p. 545.

[3] *Proceedings,* Am. Soc. Testing Mats., Vol. 26, Part I, p. 881 (1926); also 1926 Book of A.S.T.M. Tentative Standards, p. 578.

Figure 3.—Replace the present figure, illustrating the distillation apparatus assembly, with a figure conforming to the accompanying Fig. 2 in which a cylindrical shield is shown and also a tapered condenser tube.

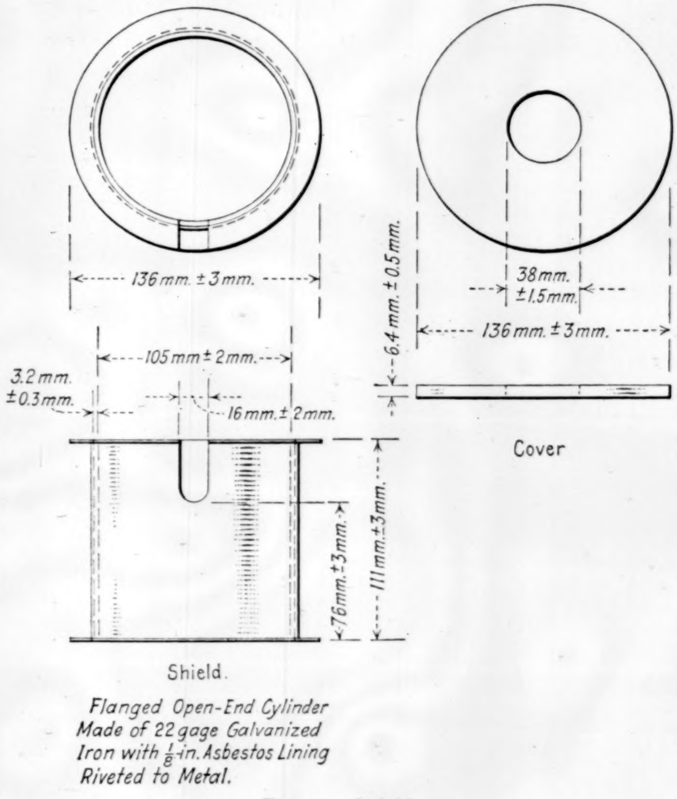
136 mm. ± 3 mm.
38 mm. ± 1.5 mm.
136 mm. ± 3 mm.
6.4 mm. ± 0.5 mm.
105 mm ± 2 mm.
3.2 mm. ± 0.3 mm.
16 mm. ± 2 mm.
Cover
111 mm. ± 3 mm.
76 mm. ± 3 mm.
Shield.
Flanged Open-End Cylinder Made of 22 gage Galvanized Iron with 1/8-in. Asbestos Lining Riveted to Metal.

FIG. 1.—Shield.

Section 3. Condenser Tube.—Add to the table of requirements for dimensions of the condenser tube appearing in this section the following requirement on the length of the tapered portion:

"Length of tapered part.................. 100.00 mm. ± 5 mm."

Section 10(d).—Change the first sentence to read as follows by the addition of the italicized words and the omission of those in brackets:

"The results *of the distillation test* shall be reported in [per cent] *percentages* by weight of [the 100 g. of sample taken] *water-free material.*

It is recommended that this method of test as revised be continued as tentative.

PROPOSED ADVANCEMENT TO STANDARD OF EXISTING TENTATIVE SPECIFICATIONS AND METHODS OF TEST

No criticisms having been received on the following tentative specifications and methods of test, the committee recommends that they be advanced to standard:

1. Tentative Specifications for Broken Slag for Bituminous Macadam Base (D 195 - 24 T);[1]

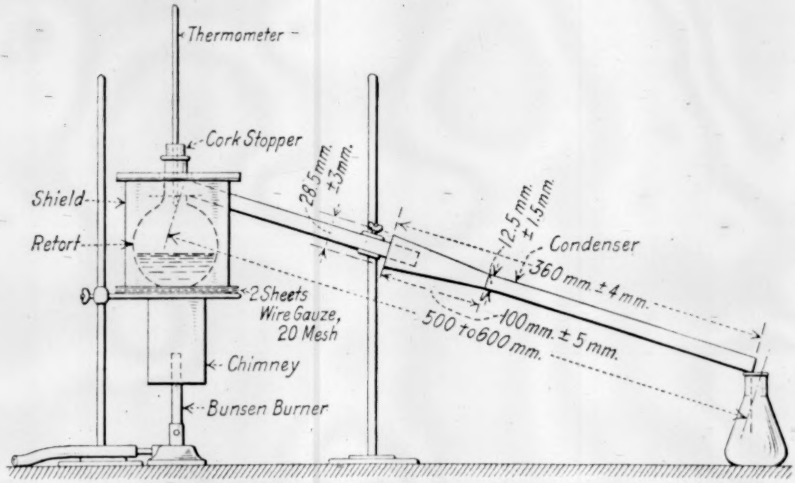
Thermometer
Cork Stopper
Shield
Retort
28.5 mm. ±3 mm.
12.5 mm. ±1.5 mm.
Condenser
360 mm. ± 4 mm.
2 Sheets Wire Gauze, 20 Mesh
100 mm. ± 5 mm.
500 to 600 mm.
Chimney
Bunsen Burner

FIG. 2.—Distillation Apparatus Assembly.

2. Tentative Specifications for Broken Slag for Bituminous Concrete Base (D 196 - 24 T);[1]
3. Tentative Specifications for Broken Slag for Bituminous Macadam Wearing Course (D 159 - 24 T);[1]
4. Tentative Specifications for Broken Slag for Bituminous Concrete (Coarse-Graded Aggregate Type) (D 160 - 24 T);[1]
5. Tentative Specifications for Broken Slag for Bituminous Concrete (Fine-Graded Aggregate Type) (D 161 - 24 T);[1]
6. Tentative Method of Float Test for Bituminous Materials (D 139 - 25 T);[2]

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 24, Part I, pp. 912–919 (1924); also 1926 Book of A.S T.M. Tentative Standards, pp. 507–514.

[2] *Proceedings*, Am. Soc. Testing Mats., Vol. 25, Part I, p. 748 (1925); also 1926 Book of A.S.T.M. Tentative Standards, p. 586.

7. Tentative Method of Test for Specific Gravity of Road Oils, Road Tars, Asphalt Cements and Soft Tar Pitches (D 70 - 26 T);[1]

8. Tentative Method of Test for Specific Gravity of Asphalts and Tar Pitches Sufficiently Solid to be Handled in Fragments (D 71 - 26 T);[1]

TABLE II.

Items	Affirmative	Negative	Not Voting
I. Proposed Revision of Existing Standards			
Standard Method of Mechanical Analysis of Sand or Other Fine Highway Material Except Fine Aggregate Used in Cement Concrete (D 7 - 18)	45	0	28
Standard Method of Test for Loss on Heating of Oil and Asphaltic Compounds (D 6 - 20)	41	0	32
II. Proposed Revision of Existing Tentative Standards			
Tentative Specifications for High-Carbon Tar for Surface Treatment, Hot Application (D 108 - 23 T)	32	0	41
Tentative Specifications for High-Carbon Tar Cement (D 110 - 25 T)	32	0	41
Tentative Specifications for Coal-Tar Pitch for Stone Block Filler (D 112 - 23 T)	29	1	43
Tentative Specifications for High-Carbon Tar for Surface Treatment, Cold Application (D 104 - 23 T)	32	0	41
Tentative Specifications for Low-Carbon Tar for Surface Treatment, Cold Application (D 105 - 23 T)	32	0	41
Tentative Specifications for High-Carbon Tar Cement for Use Cold in Repair Work (Cut-Back Product) (D 106 - 25 T)	32	0	41
Tentative Specifications for Low-Carbon Tar Cement for Use Cold in Repair Work (Cut-Back Product) (D 107 - 23 T)	32	0	41
Tentative Specifications for Low-Carbon Tar for Surface Treatment, Hot Application (D 109 - 23 T)	32	0	41
Tentative Specifications for Low-Carbon Tar Cement (D 111 - 23 T)	32	0	41
Tentative Method of Test for Distillation of Bituminous Materials Suitable for Road Treatment (D 20 - 26 T)	39	1	33
III. Proposed Advancement of Tentative Specifications and Methods of Test to Standard			
Tentative Specifications for Broken Slag for Bituminous Macadam Base (D 195 - 24 T)	39	1	33
Tentative Specifications for Broken Slag for Bituminous Concrete Base (D 196 - 24 T)	39	1	33
Tentative Specifications for Broken Slag for Bituminous Macadam Wearing Course (D 159 - 24 T)	38	2	33
Tentative Specifications for Broken Slag for Bituminous Concrete (Coarse-Graded Aggregate Type) (D 160 - 24 T)	38	2	33
Tentative Specifications for Broken Slag for Bituminous Concrete (Fine-Graded Aggregate Type) (D 161 - 24 T)	38	2	33
Tentative Method of Float Test for Bituminous Materials (D 139 - 25 T)	41	0	32
Tentative Method of Test for Specific Gravity of Road Oils, Road Tars, Asphalt Cements and Soft Tar Pitches (D 70 - 26 T)	41	0	32
Tentative Method of Test for Specific Gravity of Asphalts and Tar Pitches Sufficiently Solid to be Handled in Fragments (D 71 - 26 T)	41	0	32
Tentative Method of Test for the Determination of Bitumen (D 4 - 26 T)	38	2	33
Tentative Method of Test for the Determination of Proportion of Bitumen Soluble in Carbon Tetrachloride (D 165 - 26 T)	38	2	33
IV. Proposed Withdrawal of Existing Standard			
Standard Method of Test for Distillation of Bituminous Materials Suitable for Road Treatment (D 20 - 18)	40	1	

9. Tentative Method of Test for the Determination of Bitumen (D 4 - 26 T);[1]

10. Tentative Method of Test for the Determination of Proportion of Bitumen Soluble in Carbon Tetrachloride (D 165 - 26 T).[1]

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 26, Part I, pp. 869–873, 876–880 (1926); also 1926 Book of A.S.T.M. Tentative Standards, pp. 562–566, 573–577.

PROPOSED WITHDRAWAL OF STANDARD METHOD OF TEST

Standard Method of Test for Distillation of Bituminous Materials Suitable for Road Treatment (D 20 - 18).[1]—Because this method is being replaced by a new tentative method, the committee recommends that the standard method be withdrawn.

The results of letter ballot upon the recommendations made in this report are given in Table II.

This report has been submitted to letter ballot of the committee, which consists of 73 members, of whom 47 have voted affirmatively, none negatively, and 26 have refrained from voting.

Respectfully submitted on behalf of the committee,

JULIUS ADLER,
Chairman.

PRÉVOST HUBBARD,
Secretary.

EDITORIAL NOTE

The proposed revisions of the Standard Method of Mechanical Analysis of Sand or Other Fine Highway Material Except Fine Aggregate Used in Cement Concrete; and Method of Test for Loss on Heating of Oil and Asphaltic Compounds, were approved at the annual meeting by a nine-tenths vote and were subsequently adopted by letter ballot of the Society on September 1, 1927. The methods as revised appear in the 1927 Book of A.S.T.M. Standards, Part II.

The following tentative specifications and methods were approved at the annual meeting and subsequently adopted by letter ballot of the Society on September 1, 1927: for Broken Slag for Bituminous Macadam Base; for Broken Slag for Bituminous Concrete Base; for Broken Slag for Bituminous Macadam Wearing Course; for Broken Slag for Bituminous Concrete (Coarse-Graded Aggregate Type); Method for Broken Slag for Bituminous Concrete (Fine-Graded Aggregate Type); Method of Float Test for Bituminous Materials; of Test for Specific Gravity of Road Oils, Road Tars, Asphalt Cements and Soft Tar Pitches; of Test for Specific Gravity of Asphalts and Tar Pitches Sufficiently Solid to be Handled in Fragments; of Test for the Determination of Bitumen; and of Test for the Determination of Proportion of Bitumen Soluble in Carbon Tetrachloride. The specifications and methods appear in the 1927 Book of A.S.T.M. Standards, Part II.

The proposed revisions of the following tentative specifications and method were accepted: for High-Carbon Tar for Surface Treatment, Hot Application;

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[1] 1924 Book of A.S.T.M. Standards.

for High-Carbon Tar Cement; for Coal-Tar Pitch for Stone Block Filler; for High-Carbon Tar for Surface Treatment, Cold Application; for Low-Carbon Tar for Surface Treatment, Cold Application; for High-Carbon Tar Cement for Use Cold in Repair Work (Cut-Back Product); for Low-Carbon Tar Cement for Use Cold in Repair Work (Cut-Back Product); for Low-Carbon Tar for Surface Treatment, Hot Application; for Low-Carbon Tar Cement; and Method of Test for Distillation of Bituminous Materials Suitable for Road Treatment. The specifications and method as revised appear on pages 936 to 958.

The Standard Method of Test for Distillation of Bituminous Materials Suitable for Road Treatment was withdrawn.

REPORT OF COMMITTEE D-5

ON

COAL AND COKE

Committee D-5 has held three meetings during the past year. It suggests amendments to the tentative revisions of the Standard Methods of Laboratory Sampling and Analysis of Coal[1] which are now recommended for adoption as standard as amended. The tentative revisions of the Standard Methods of Laboratory Sampling and Analysis of Coke[2] are also recommended for adoption as standard. The Tentative Definitions of Terms Relating to Coal and Coke (D 121 - 26 T) have been given careful consideration and some of the definitions, as mentioned later in this report, are recommended for advancement to standard with certain minor changes in wording, the others are recommended to be continued as tentative pending further changes. The Tentative Method of Test for Fineness of Powdered Coal (D 197 - 26 T) is recommended for continuation as tentative pending investigation of sampling methods.

Sub-Committee I on Methods of Testing has been very active in the past year. Methods for determination of sulfur in the bomb washings following the calorimetric determination, and by sodium peroxide fusion have been carefully investigated and are recommended for publication as tentative methods. A special sub-committee has made considerable progress in assembling data for proposed tests to determine cubic foot weights and sieve tests of crushed bituminous coal and of coke. Another sub-committee has assembled information regarding the tumbler test for coke as used at the present time.

Sub-Committee IV on Standard Sizes is continuing its work on a proposed method for size testing of anthracite. Sampling methods and allowable tolerances when sizing anthracites of different hardness are being investigated.

Sub-Committee V on Tolerances was inactive during the past year due to the resignation of its chairman. Another chairman has been appointed and the sub-committee expects to conduct cooperative sampling experiments to obtain information on allowable tolerances when different samplers collect samples of the same lot of coal.

Sub-Committee VI on Agglutinating Value has made agglutinating tests on a number of coals to find out if such tests are indicative of use properties of the coals. Sufficient tests have not been made to pass on the value of such testing.

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 26, Part I, pp. 1132–1136 (1926).

[2] *Ibid.*, p. 1131.

To effect economy in printing and convenience in use the Standard Methods of Laboratory Sampling and Analysis of Coke have been combined with those of coal and are recommended for publication in the combined form.

The recommendation of Committee E-1 on Methods of Testing that the micron designation be used for sieves has been approved and adopted by Committee D-5. The committee will use this micron designation and will include the sieve number designation in parenthesis for the benefit of those familiar with the number designation.

TENTATIVE REVISIONS RECOMMENDED FOR ADOPTION AS STANDARD

Tentative Revisions of Standard Methods of Laboratory Sampling and Analysis of Coke (D 37 - 24).[1]—Tentative revisions of the Standard Methods of Laboratory Sampling and Analysis of Coke appear on page 1131 of Part I of Volume 26 of the Proceedings of the Society as presented by Committee D-5 in 1925. No criticisms of these tentative revisions have been received. The committee now recommends their adoption as standard, incorporating the revisions in the proposed combined methods of analysis of coal and coke.

Tentative Revisions of Standard Methods of Laboratory Sampling and Analysis of Coal (D 22 - 24).[1]—Tentative revisions of the Standard Methods of Laboratory Sampling and Analysis of Coal appear on pages 1132–1136 of Part I of Volume 26 of the Proceedings of the Society as presented by Committee D-5 in 1925 and 1926. To furnish more detailed information concerning the use of optical pyrometers Committee D-5 recommends that these revisions be further amended as follows:

Under "*Observation Hole*" change the second sentence from its present form: namely,

> "A brass sleeve carrying a thin glass window is slipped on the outer end of the observation tube to prevent the escape of burning gas, which would interfere with a convenient observation of the cones."

to read as follows:

> "A brass sleeve carrying a single thin glass window made from ordinary soda glass is slipped on the outer end of the observation tube to prevent the escape of burning gas which would interfere with a convenient observation of the cones."

Include a footnote reference under "*Pyrometer*" to read as follows:

> "For detailed information concerning the use of pyrometers see Pyrometric Practice, U. S. Bureau of Standards *Technologic Paper No. 170* (1921)."

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[1] 1924 Book of A.S.T.M. Standards.

Insert a second paragraph under "*Pyrometer*" to read as follows:

"When an optical pyrometer is sighted through a glass window, the following corrections shall be applied to the observed temperatures to correct for the loss of light at the glass window of the observation tube.

CORRECTION TO OBSERVED TEMPERATURE FOR ABSORPTION OF LIGHT BY A SINGLE CLEAN GLASS WINDOW.[a]

OBSERVED TEMPERATURE, DEG. CENT.	CORRECTION TO BE ADDED, DEG. CENT.
800	5
1000	8
1200	10
1400	13
1600	16

[a] U. S. Bureau of Standards *Technologic Paper No. 170*, p. 117 (1921).

Committee D-5 recommends that the revisions as amended be adopted as standard, incorporating the revisions in the proposed combined methods of analysis of coal and coke.

COMBINATION OF STANDARD METHODS OF ANALYSIS

To effect economy in printing and convenience in use, the committee believes that the Standard Methods of Laboratory Sampling and Analysis of Coke (D 37) and the Standard Methods of Laboratory Sampling and Analysis of Coal (D 22) should be combined. The methods for coal and coke are identical in many instances so very well lend themselves to combination. The methods in their proposed combined form are appended hereto.[1] The combination is a change in form only. As the committee has adopted the micron designation of sieves this designation is used in the proposed combination, with the sieve number designation in parenthesis. The proposed revisions have also been incorporated.

Committee D-5 recommends that the two present standard methods be withdrawn and the combined methods appended hereto[1] be accepted for publication as standard.

TENTATIVE STANDARDS RECOMMENDED FOR ADOPTION AS STANDARD

Tentative Definitions of Terms Relating to Coal and Coke. (D 121 - 26 T).[2]—Sub-Committee II on Nomenclature and Definitions referred the tentative definitions of terms to Committee E-8 on Nomenclature and Definitions and a few minor changes in wording have been agreed upon. The sub-committee has recommended that the definitions of the terms "proximate analysis," "ultimate analysis," "moisture," "ash," "volatile matter," and "fixed carbon" be recommended for advancement to standard in their revised form. These definitions have been approved by Committee E-8. Further recommendations of the sub-committee were to continue as tentative, pending further revision, the present definitions of the terms "coke," "beehive coke," "by-product coke," "coke breeze," and "dry coke."

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[1] See 1927 Book of A.S.T.M. Standards, Part II, p. 535.

[2] *Proceedings*, Am. Soc. Testing Mats., Vol. 26, Part I, p. 903 (1926); also 1926 Book of A.S.T.M. Tentative Standards, p. 604.

Committee D-5 has concurred in the recommendations of the sub-committee and recommends that the revised definitions appended hereto[1] be adopted as standard and that the remaining definitions be continued as tentative.

Proposed New Tentative Standards

A special sub-committee of Sub-Committee I on Methods of Testing has done considerable work on the bomb-washing and sodium-peroxide fusion methods for determination of sulfur in coal and coke and has compared the results obtained by these methods with those of the standard Eschka method. Sixteen samples of coal and coke, ranging in sulfur content from about 0.5 to 17.0 per cent, were analyzed by five different laboratories by the Eschka, bomb-washing, and sodium-peroxide fusion methods. The laboratories were given detailed instructions on the procedure to be used for each method. In general, the laboratories obtained results with the bomb-washing and sodium-peroxide fusion methods which checked those of the Eschka method sufficiently close to show that these methods may be used as alternate methods for the Eschka method. The detailed results of this investigation were published in the June 1927 issue of the *Journal of Industrial and Engineering Chemistry*.

At the present time the bomb-washing method is widely used, as it is very convenient to determine sulfur in the washings from the oxygen bomb calorimeter following the calorimetric determination. The sodium-peroxide fusion method is also a convenient and rapid method and is used by many laboratories. Committee D-5 recommends that the proposed Tentative Methods for the Determination of Sulfur in Coal and Coke by the Bomb-Washing and Sodium Peroxide Fusion Methods, appended hereto,[2] be accepted for publication as tentative pending their final adoption as alternate methods with the present Eschka method.

Methods Proposed as Information

Appended hereto are proposed methods for determining cubic foot weights and sieve analysis of coal and coke as submitted by a special sub-committee under the chairmanship of O. O. Malleis. The methods are under consideration in the sub-committee.

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[1] See 1927 Book of Standards, Part II, p. 579.

[2] See p. 959.—Ed.

The results of the letter ballot of the committee, which consists of 44 members, on the recommendations contained in this report are as follows:

Items	Affirmative	Negative	Not Voting
I. TENTATIVE REVISIONS RECOMMENDED FOR ADOPTION AS STANDARD			
Tentative Revisions of Standard Methods of Laboratory Sampling and Analysis of Coke (D 37 - 24)	37	0	7
Tentative Revisions of Standard Methods of Laboratory Sampling and Analysis of Coal (D 22 - 24)	37	0	7
II. PROPOSED COMBINATION OF STANDARDS			
Combination of Standard Methods of Laboratory Sampling and Analysis of Coke (D 37) with the Standard Methods of Laboratory Sampling and Analysis of Coal (D 22)	37	0	7
III. TENTATIVE STANDARD RECOMMENDED FOR ADOPTION AS STANDARD			
Tentative Definitions of Terms Relating to Coal and Coke (D 121 - 26 T)	36	0	8
IV. PROPOSED NEW TENTATIVE STANDARD			
Methods of Determination of Sulfur in Coal and Coke by the Bomb-Washing and Sodium-Peroxide Fusion Methods	36	0	8

This report has been submitted to letter ballot of the committee, which consists of 44 members, of whom 37 have voted affirmatively, none negatively, and 7 have refrained from voting.

Respectfully submitted on behalf of the committee,

A. C. FIELDNER,
Chairman.

W. A. SELVIG,
Secretary.

H. C. PORTER,
Vice-Chairman.

EDITORIAL NOTE

The tentative revisions of the Standard Methods of Laboratory Sampling and Analysis of Coke; and Laboratory Sampling and Analysis of Coal, amended as recommended by the committee, were approved at the annual meeting and subsequently adopted by letter ballot of the Society on September 1, 1927. The proposed combination of the Standard Methods of Laboratory Sampling and Analysis of Coke and the Standard Methods of Laboratory Sampling and Analysis of Coal was approved. The methods as revised appear in the 1927 Book of A.S.T.M. Standards, Part II.

The proposed Method for the Determination of Sulfur in Coal and Coke by the Bomb-Washing and Sodium Peroxide Fusion Methods were accepted for publication as tentative as a revision of the Standard Methods of Laboratory Sampling and Analysis of Coal and Coke. The tentative methods appear on page 959.

The Tentative Definitions of Terms Relating to Coal and Coke, revised as recommended by the committee, were approved at the annual meeting and subsequently adopted by letter ballot of the Society on September 1, 1927. The definitions appear in the 1927 Book of A.S.T.M. Standards, Part II.

APPENDIX I

PROPOSED METHOD OF TEST FOR CUBIC FOOT WEIGHT OF COKE

Apparatus

1. *Cubic Foot Box.*—A box 24 by 24 by 24 in. in inside dimensions shall be used. In order to keep the weight of the empty box as light as possible, the box may be made of wood but must be rigid. Two strips of wood may be fastened to the sides of the box to form "sedan-chair" handles for convenience in handling.

Note.—For determining the cubic foot weights of coke smaller than 1 in. in size, a one cubic foot box measuring 12 by 12 by 12 in. in inside dimensions may be used.

Sampling

2. For collecting samples of coke, the directions of the Standard Method of Sampling Coal (Serial Designation: D 21) of the American Society for Testing Materials[1] shall apply in general. For run-of-oven coke and for coke retained on about a 1-in. screen, at least 300 lb. shall be taken. For coke smaller than 1 in., about 50 lb. shall be taken. It is extremely difficult to obtain truly representative samples of coke having a range of sizes. The samples shall be taken when the coke is on a belt conveyor by stopping the belt and taking about 3-ft. sections across the entire width of the belt or by inserting a device into the coke stream so as to take the full thickness and width of the coke stream where the coke is going over a pulley or coming down a chute. The increments shall be regularly and systematically collected, so that the entire quantity of the coke sampled will be represented proportionately in the sample, and with such frequency that a sample of the required amount shall be collected. It is not feasible to collect representative samples of coke from loaded cars or bins for cubic foot weight determinations. Samples of coke in cars or bins should be taken as the cars or bins are being filled or emptied.

Procedure

3. The cubic foot weight box should be placed on a suitable platform scale, weighed empty and then filled with coke while the box is on the scale in order to avoid handling a heavy box of coke. The box shall be filled by allowing the coke to slide out of a shovel or suitable container at a height of 2 in. above the top of the box, with no attempt to spread or arrange the coke. Because of the physical character of coke, it is not practical to strike off the excess coke by means of a straight edge, so it is necessary to do this largely by eye, with the assistance of a straight edge to check observations. The box

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[1] **1927 Book of A.S.T.M. Standards, Part II.**

must not be shaken, tapped or dropped during filling or leveling off. The box with coke shall then be weighed. The difference between the two weights divided by the number of cubic feet in the box will give the weight per cubic foot of coke.

NOTE.—For proper interpretation of cubic foot weight of coke, a moisture determination and a sieve analysis of the coke should be reported along with the cubic foot weight.

APPENDIX II

PROPOSED METHOD OF TEST FOR CUBIC FOOT WEIGHT OF CRUSHED BITUMINOUS COAL

Apparatus

1. *Cubic Foot Box.*—A box 12 by 12 by 12 in. in inside dimensions shall be used. A box made of $\frac{1}{8}$-in. sheet steel welded together and provided with handles, makes a very suitable cubic foot box and would weigh approximately 35 lb.

Sampling

2. For collecting the sample of crushed bituminous coal, the directions of the Standard Method of Sampling Coal (Serial Designation: D 21) of the American Society for Testing Materials[1] shall apply. The sample shall be collected in a waterproof container with a tightly fitting cover to prevent loss of moisture during the period of collection.

Procedure

3. The sample of coal shall be thoroughly mixed and reduced by quartering, without crushing, in accordance with the Standard Method of Sampling Coal (Serial Designation: D 21), of the American Society for Testing Materials[1] as quickly as possible to avoid loss of moisture, to approximately 60 lb. The cubic foot weight should be determined immediately. If the test for cubic foot weight is not to be made immediately, the 60 lb. should, of course, be kept in a waterproof container with a tightly fitting cover until the time for making the cubic foot weight.

4. The cubic foot box shall be weighed empty, and shall then be filled by means of a scoop or small shovel by allowing the coal to slowly slide off the scoop or shovel at a height of about 2 in. above the top of the box until the coal overflows on all sides of the box. Precaution should be taken that none of the coal is dropped into the box so as to cause packing and that the cubic foot box is not shaken or tapped during filling. The excess coal shall be struck off by means of straight edge without shaking or tapping the cubic foot box. The box with coal shall then be weighed. The difference between the two weights to the 0.1 lb. shall be reported as the weight of one cubic foot of the coal.

Note.—Aside from the character of the coal itself, moisture content and size of the coal are the two main factors which affect the cubic foot weight. A moisture determination and a sieve analysis should be reported along with the cubic foot weight for proper interpretation of the cubic foot weight.

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[1] 1927 Book of A.S.T.M. Standards, Part II.

APPENDIX III

PROPOSED METHOD OF TEST FOR SIEVE ANALYSIS OF COKE

APPARATUS

1. *Sieves.*—The following square mesh sieves, so selected that the sizes of the successive openings have a constant ratio of 1.414 (the square root of 2), in so far as this sieve scale has become established by use, shall be used: 0.131, 0.185, 0.263, 0.371, 0.525, 0.742, 1.050, 1.5, 2.0, 3.0 and 4.0 in. For sizes smaller than 2 in., circular sieves of double crimped wire and about 18 in. in diameter are satisfactory. For coke 2 in. and larger in size, it is more convenient to use sieves square or rectangular in shape of heavy double crimped wire having an area of 6 to 9 square feet. These larger sieves may be mounted in a rack so as to slide like a drawer with a pan at the bottom.

SAMPLING

2. For collecting samples of coke, the directions for the Standard Method of Sampling Coal (Serial Designation: D 21) of the American Society for Testing Materials[1] shall apply in general. The weight of sample to be taken will be dependent upon the size and character of the coke as follows:

For run-of-oven coke and coke over 1 in. in size containing breeze	not less than 500 lb.
For coke 1 in. and larger, free from breeze	not less than 200 lb.
For coke smaller than 1 in	not less than 50 lb.

It is extremely difficult to obtain truly representative samples of coke having a range of sizes. The samples shall be taken when the coke is on a belt conveyor by stopping the belt and taking about 3-ft. sections across the entire width of the belt or by inserting a device into the coke stream so as to take the full thickness and width of the coke stream where the coke is going over a pulley or coming down a chute. The increments shall be regularly and systematically collected, so that the entire quantity of coke sampled will be represented proportionately in the sample, and with such frequency that a sample of the required amount shall be collected. It is not feasible to collect representative samples of coke from loaded cars or bins for sieve tests. Samples of coke in cars or bins should be taken as the cars or bins are being filled or emptied.

PROCEDURE

3. The entire sample taken shall be weighed for the sieve tests. For coke pieces 2 in. and larger, each piece shall be upended, that is, tested to see if it will pass the sieve in any position. For coke pieces smaller than 2 in., the coke shall be shaken rather vigorously in order to upend the pieces until practically no more coke will pass through the openings. Starting with the sieve having the largest opening, the coke shall be sieved in such increments as will allow

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[1] **1927 Book of A.S.T.M. Standards, Part II.**

the pieces to be in direct contact with the meshes after the completion of the shaking of each increment. The coke retained on each sieve and that which passes the smallest sieve used shall be weighed separately. If the sum of these weights shows a loss of over 0.5 per cent the test shall be rejected and another test made. In case the coke is wet, the coke shall be dried before making the sieve test. However, usually any error due to moisture content would be very small and may be neglected except in case of coke smaller than 1 in., in which case the coke should be dried before making the sieve test.

4. For coke 1 in. and larger in size the following sieves are usually used: 4.0, 3.0, 2.0, 1.5, 1.050 and 0.525 in. For coke smaller than 1 in. the sieves usually used are: 0.742, 0.525, 0.371, 0.263, 0.185 and 0.131 in.

The results of the sieve tests shall be reported to 0.1 per cent as follows:

	PER CENT
Retained on a 4.0-in. sieve	
Passing a 4.0-in. sieve and retained on a 3.0-in. sieve	
Passing a 3.0-in. sieve and retained on a 2.0-in. sieve	
Passing a 2.0-in. sieve and retained on a 1.5-in. sieve	
Passing a 1.5-in. sieve and retained on a 1.050-in. sieve	
Total	100.0

In case the sum of the percentages do not total 100.0, correction should be made on the quantity passing through the smallest sieve so that the total will be 100.0.

In view of the difficulty of obtaining representative samples of coke with regard to the size of pieces, even when 500 lb. samples are used for the sieve test, it is desirable to take several samples for sieve tests and average the figures for the several samples.

APPENDIX IV

PROPOSED METHOD OF TEST FOR SIEVE ANALYSIS OF CRUSHED BITUMINOUS COAL

Apparatus

1. *Sieves.*—The following square mesh sieves, so selected that the sizes of the successive openings have a constant ratio of 1.414 (the square root of 2), shall be used: 0.131, 0.185, 0.263, 0.371, 0.525, 0.742 and 1.050 in. Circular sieves made of double crimped wire and about 18 in. in diameter are satisfactory.

Sampling

2. For collecting the sample of crushed bituminous coal, the directions of the Standard Method of Sampling Coal (Serial Designation: D 21) of the American Society for Testing Materials[1] shall apply.

Procedure

3. The sample of coal shall be thoroughly mixed and reduced by quartering without crushing according to the Standard Method of Sampling Coal (Serial Designation: D 21) of the American Society for Testing Materials to approximately 60 lb. In case the coal is wet, the entire sample shall be air dried before reduction to 60 lb. The entire reduced sample (approximately 60 lb.) shall be weighed out for the sieve test.

4. In sieving, the coal shall be shaken rather vigorously in order to upend the pieces until practically no more coal will pass through the openings. Starting with the sieve having the largest opening, the coal should be sieved in such increments as will allow the pieces to be in direct contact with the meshes after completion of the shaking of each increment. The coal retained on each sieve and that which passes through the finest sieve shall be weighed separately. If the sum of these weights shows a loss of over 0.5 per cent, the test shall be rejected and another made.

5. The results of the sieve test shall be reported to 0.1 per cent as follows:

	Per Cent
Retained on a 1.050-in. sieve	....
Passing a 1.050-in. sieve and retained on a 0.742-in. sieve	....
Passing a 0.742-in. sieve and retained on a 0.525-in. sieve	....
Passing a 0.525-in. sieve and retained on a 0.371-in. sieve	....
Passing a 0.371-in. sieve and retained on a 0.263-in. sieve	....
Passing a 0.263-in. sieve and retained on a 0.185-in. sieve	....
Passing a 0.185-in. sieve and retained on a 0.131-in. sieve	....
Passing a 0.131-in. sieve	....
Total	100.0

In case the sum of the percentages do not total 100.0, correction should be made on the quantity passing through the smallest sieve so that the total will be 100.0.

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[1] 1927 Book of A.S.T.M. Standards, Part II.

REPORT OF COMMITTEE D-7

ON

TIMBER

During the past year Committee D-7 on Timber has been engaged in a final revision of the specifications for structural timbers of southern pine and Douglas fir covered by the Specifications for Structural Joist, Planks, Beams, Stringers and Posts (D 245 – 26 T),[1] submitted as tentative a year ago. As a result of this work, the committee this year submits, with the recommendation for the adoption as standard, the revision of the tentative specification appended hereto.[2] The report of Sub-Committee I on Specifications for Timber is appended hereto which presents the proposed standard specification for structural timber. Attention should be called to the fact that the American Railway Engineering Association at its convention in March of this year adopted these revised specifications as standard. Acknowledgment is made for the helpful cooperation of the members of committees of other organizations.

Sub-Committee VI on Timber Preservatives has conducted cooperative work with committees of the American Railway Engineering Association and the American Wood-Preservers' Association. The report of this sub-committee is appended transmitting recommendation for the adoption as standard of a number of methods which have been tentative for a number of years.

Sub-Committee IX on Methods of Testing this year presents the recommendation to adopt as standard two methods that have been published as tentative for the past few years. This report is attached.

During the past year a new Sub-Committee on Moisture Content was appointed. The accurate determination of moisture content of timber is becoming increasingly important. The work of the new sub-committee has been directed towards developing a method or methods for determining the water content in timber. This committee has made good progress and offers a report published herewith as information.

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 26, Part I, p. 906 (1926): also 1926 Book of A.S.T.M. Tentative Standards, p. 607.

[2] See 1927 Book of A.S.T.M. Standards, Part II, p. 581.—Ed.

Committee D-7 makes the following recommendations:

1. That the Standard Specifications for Yellow Pine Bridge and Trestle Timbers (D 10 - 15)[1] be withdrawn. These standard specifications will be superseded by the proposed new standard specifications.

2. That the Standard Specifications for Southern Yellow Pine Timber to be Creosoted (D 24 - 20)[1] be withdrawn. These standard specifications will be superseded by the new standard specification.

3. That the Tentative Specifications for Structural Joist, Planks, Beams, Stringers and Posts (D 245 - 26 T),[2] amended as appended to this report,[3] be adopted as standard.

4. That the Tentative Methods of Testing Small Clear Specimens of Timber (D 143 - 24 T)[4] be advanced to standard.

5. That the Tentative Methods of Conducting Static Tests of Timber in Structural Sizes (D 198 - 24 T)[5] be advanced to standard.

6. That the Tentative Method of Test for Coke Residue of Creosote Oil (D 168 - 23 T)[6] be advanced to standard.

7. That the Tentative Methods of Chemical Analysis of Zinc Chloride (D 199 - 24 T)[7] be advanced to standard.

8. That the Tentative Method of Test for Distillation of Creosote Oil (D 246 - 26 T)[8] be revised as recommended in the report of Sub-Committee VI on Timber Preservatives appended hereto, and that the methods as revised be continued as tentative.

If the recommendations of Committee D-7 are approved, the committee will have but one tentative standard, namely, the Tentative Method of Test for Distillation of Creosote Oil (D 246 - 26 T). A revision of this tentative method is being recommended this year as mentioned above.

The recommendations appearing in this report have been submitted to letter ballot of the committee with the following results:

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[1] 1924 Book of A.S.T.M. Standards.

[2] *Proceedings*, Am. Soc. Testing Mats., Vol. 26, Part I, p. 906 (1926); also 1926 Book of A.S.T.M. Tentative Standards, p. 607.

[3] See 1927 Book of A.S.T.M. Standards, Part II, p. 581.—Ed.

[4] *Proceedings*, Am. Soc. Testing Mats., Vol. 24, Part I, p. 939 (1924); also 1926 Book of A.S.T.M. Tentative Standards, p. 644.

[5] *Proceedings*, Am. Soc. Testing Mats., Vol. 24, Part I, p. 976 (1924); also 1926 Book of A.S.T.M. Tentative Standards, p. 681.

[6] *Proceedings*, Am. Soc. Testing Mats., Vol. 23, Part I, p. 771 (1923); also 1926 Book of A.S.T.M. Tentative Standards, p. 700.

[7] *Proceedings*, Am. Soc. Testing Mats., Vol. 24, Part I, p. 995 (1924); also 1926 Book of A.S.T.M. Tentative Standards, p. 707.

[8] *Proceedings*, Am. Soc. Testing Mats., Vol. 26, Part I, p. 943 (1926); also 1926 Book of A.S.T.M. Tentative Standards, p. 702.

Items	Affirmative	Negative	Not Voting
I. WITHDRAWAL OF STANDARDS			
1. Standard Specifications for Yellow Pine Bridge and Trestle Timbers (D 10 - 15).....	23	0	3
2. Standard Specifications for Southern Yellow Pine Timber to be Creosoted (D 24 - 20).	23	0	3
II. TENTATIVE STANDARDS ADVANCED TO STANDARD			
3 Tentative Specifications for Structural Joist, Planks, Beams, Stringers and Posts (D 245 - 26 T), as amended..	23	0	3
4. Tentative Methods of Testing Small Clear Specimens of Timber (D 143 - 24 T).....	23	0	3
5. Tentative Methods for Conducting Static Tests in Timber of Structural Sizes (D 198 - 24 T)..	22	0	4
6. Tentative Method of Test for Coke Residue of Creosote Oil (D 168 - 23 T)..........	18	0	8
7. Tentative Methods of Chemical Analysis of Zinc Chloride (D 199 - 24 T)...........	18	0	8
III. REVISION OF TENTATIVE STANDARD			
8. Tentative Method of Test for Distillation of Creosote Oil (D 246 - 26 T)............	23	0	3

This report has been submitted to letter ballot of the committee, which consists of 26 members, of whom 22 have voted affirmatively, none negatively, and 4 have refrained from voting.

Respectfully submitted on behalf of the committee,

HERMANN VON SCHRENK,
Chairman.

J. A. NEWLIN,
Secretary.

EDITORIAL NOTE

The Tentative Specifications for Structural Joist, Planks, Beams, Stringers and Posts, revised as recommended by the committee, were approved at the annual meeting and subsequently adopted by letter ballot of the Society on September 1, 1927, to replace the present Standard Specifications for Yellow Pine Bridge and Trestle Timbers; and for Southern Yellow Pine Timber to be Creosoted. The specifications appear in the 1927 Book of A.S.T.M. Standards, Part II. The Tentative Methods of Testing Small Clear Specimens of Timber; for Conducting Static Tests of Timber in Structural Sizes; of Test for Coke Residue of Creosote Oil; and Chemical Analysis of Zinc Chloride, were approved at the annual meeting and subsequently adopted by letter ballot of the Society, on September 1, 1927. The methods appear in the 1927 Book of A.S.T.M. Standards, Part II.

The proposed revisions of the Tentative Method of Test for Distillation of Creosote Oil were accepted. The method as revised appears on page 963.

The Standard Specifications for Yellow Pine Bridge and Trestle Timbers; and for Southern Yellow Pine Timber to be Creosoted, were withdrawn.

REPORT OF SUB-COMMITTEE I ON SPECIFICATIONS FOR TIMBER

The specifications for structural wood joist, planks, beams, stringers and posts appended hereto[1] are intended to replace the present two standard specifications for southern pine[2] and the former tentative specifications for Douglas fir.[3]

The form of presentation and details of text have been made to agree with the findings of the joint meeting of Sub-Committee I, and the Committee on Wooden Bridges and Trestles, American Railway Engineering Association, held at the U. S. Forest Products Laboratory, Madison, Wis., in September, 1925. All specification details are based upon American Lumber Standards.

These jointly-prepared specifications were submitted by the Committee on Wooden Bridges and Trestles to the American Railway Engineering Association in March, 1926, and adopted as standard. They were presented at the 1926 annual meeting of the Society and accepted for publication as tentative. They have since been modified in minor details, but since no material changes have been made, the sub-committee now recommends that the specifications for structural timber in the form appended hereto be adopted as standard. The subject has been divided into:

A. Structural grades of lumber and timbers and the method of their derivation;

B. Specifications for structural wood joists, plank, beams, stringers, and posts;

C. A reference code as applied to structural grades, and examples of use of code;

D. Coded specifications for structural grades.

An appendix containing notes on working stresses for Douglas fir, southern pine and other softwood structural material, together with tables of values for grades complying with the provisions for structural material as set forth in the specifications appears at the end of the specifications, as information only.

Respectfully submitted on behalf of the sub-committee,

C. E. Paul,
Chairman.

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[1] See 1927 Book of A.S.T.M. Standards, Part II, p. 581.—Ed.

[2] Standard Specifications for Yellow-Pine Bridge and Trestle Timbers (Serial Designation: D 10 - 15), 1924 Book of A.S.T.M. Standards; Standard Specifications for Southern Yellow-Pine Timbers to be Creosoted (Serial Designation: D 24 - 20), 1924 Book of A.S.T.M. Standards.

[3] Tentative Specifications for Structural Douglas Fir (Serial Designation: D 23 - 20 T), *Proceedings*, Am. Soc. Testing Mats., Vol. XX, Part I, p. 704 (1920); also 1925 Book of A.S.T.M. Tentative Standards, p. 517.

The new distillation method, now common to Committee D-7 and Committee D-4 on Road and Paving Materials and adopted in 1926 by the American Wood-Preservers' Association for testing creosote oil, has been improved during the year after a considerable amount of cooperative work by the interested committees. As a result of this work a new shield is recommended to be used in place of the one now described in the Tentative Method of Test for Distillation of Creosote Oil (D 246 - 26 T). Tests made in eight laboratories on two types of creosote oil (the results of which are presented in Table I) show that the new shield gives results of the same order as the old. It is much simpler and easier to use and is preferred by all who have used it.

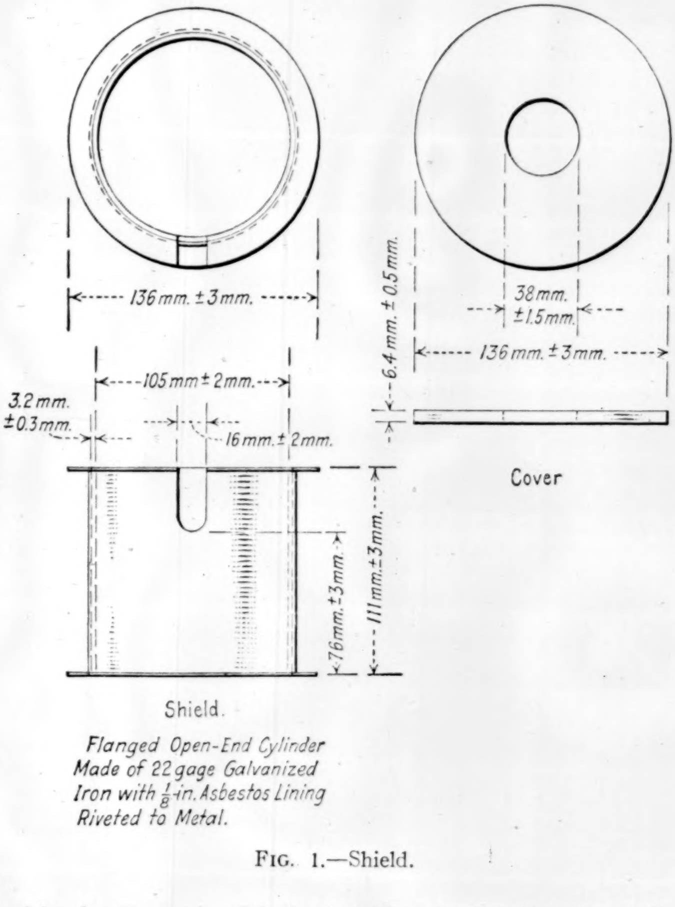
136 mm. ± 3 mm.
38 mm. ± 1.5 mm.
136 mm. ± 3 mm.
6.4 mm. ± 0.5 mm.
105 mm ± 2 mm.
3.2 mm. ± 0.3 mm.
16 mm. ± 2 mm.
Cover
76 mm. ± 3 mm.
111 mm. ± 3 mm.
Shield.
Flanged Open-End Cylinder Made of 22 gage Galvanized Iron with $\frac{1}{8}$-in. Asbestos Lining Riveted to Metal.

FIG. 1.—Shield.

In the fall of 1926, under the guidance of a joint committee representing this Society and the American Wood-Preservers' Association, duly authorized by both bodies, arrangements were made with Mr. Burgess, Director of the U. S. Bureau of Standards, for making a series of density determinations on various types of creosote oil. The purpose of this undertaking is to prepare tables for volume tem-

TABLE I.—RESULTS OF DISTILLATION TESTS ON CREOSOTE OIL, EMPLOYING THREE METHODS OF SHIELDING FLASK.

Temperature, deg. Fahr.	Method	Laboratory							
		No. 1 (1)	No. 2 (1)	No. 3 (3)	No. 4 (2)	No. 5 (2)	No. 6 (10)	No. 7[a] (2)	No. 8
CREOSOTE, GRADE 3									
0 - 210......	A........	7.4	9.9	7.5	8.3	7.4	2.4	3.8	8.3
	B........	6.7	8.6	8.1	6.2	7.7	4.3	4.7	7.0
	C........	7.3	9.4	7.8	6.6	10.1	4.6	4.6	7.2
0 - 235......	A........	31.3	35.1	36.4	34.3	34.2	25.7	24.8	33.4
	B........	29.3	33.8	33.4	29.9	28.6	28.2	25.0	30.8
	C........	32.4	35.0	32.9	30.4	32.5	27.7	26.1	32.6
0 - 270......	A........	54.2	57.2	58.8	....	56.8	55.2	51.4	55.7
	B........	54.1	57.5	57.8	....	57.2	54.8	51.5	56.4
	C........	55.4	58.9	56.2	....	59.5	55.9	52.9	56.3
0 - 315......	A........	72.9	74.4	74.2	74.2	75.4	74.6	59.6	74.0
	B........	71.9	74.6	75.2	73.2	76.8	73.6	70.0	73.8
	C........	72.4	76.7	74.0	72.8	78.7	75.2	70.2	73.1
0 - 355......	A........	88.4	88.8	88.2	89.6	89.4	88.8	84.0	89.0
	B........	87.5	88.5	89.2	88.6	89.0	88.5	85.2	90.0
	C........	88.7	90.6	88.3	88.2	90.9	89.1	84.9	90.0
Residue.....	A........	11.1	10.7	11.4	....	....	10.9	15.6	11.0
	B........	11.9	10.9	10.8	....	....	11.2	14.8	10.0
	C........	10.4	9.0	11.4	....	....	10.6	14.7	9.9
HIGH BOILING OR ANTHRACENE OIL									
0 - 210......	A........	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0
	B........	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	C........	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0 - 235......	A........	0.2	0.4	0.2	0.2	0.4	0.0	0.3	0.1
	B........	0.1	0.5	0.0	0.2	0.4	0.0	0.5	0.0
	C........	0.2	0.1	0.2	0.1	0.4	0.0	0.4	0.1
0 - 270......	A........	2.2	4.5	3.0	...	2.9	...	2.2	2.2
	B........	2.9	4.0	1.1	...	1.6	...	3.1	3.5
	C........	2.5	2.9	3.0	...	3.6	...	2.6	3.2
0 - 315......	A........	24.8	24.6	22.0	24.5	21.9	....	14.1	21.2
	B........	20.1	24.2	20.0	20.3	22.2	....	15.5	21.9
	C........	21.4	24.0	22.6	23.8	22.6	....	16.0	29.9
0 - 355......	A........	60.4	60.5	61.5	58.2	60.1	60.2	44.3	59.5
	B........	57.5	61.5	58.2	59.4	60.8	61.4	45.6	60.3
	C........	58.7	62.6	60.9	59.5	63.6	59.3	44.8	60.0
Residue.....	A........	39.2	39.1	38.1	....	....	39.5	55.3	40.5
	B........	41.9	38.3	41.7	....	....	38.3	53.6	39.7
	C........	40.2	36.5	39.2	....	....	40.5	55.6	39.9

[a] Laboratory 7, having no gas, used a Cenco Electric Heater.
Method A, employing old shield described in Method D 246 - 26 T.
Method B, employing new shield recommended in this report, plain.
Method C, employing new shield recommended in this report, with asbestos packing around the neck of the flask.

perature correction for creosote oils, similar to the abridged tables for petroleum prepared about two years ago by the Bureau. This work is being actively carried on, and its completion is expected within a few months.

The sub-committee offers the following recommendations:

1. That the Tentative Method of Test for Coke Residue of Creosote Oil (D 168 - 23 T)[1] be advanced to standard.

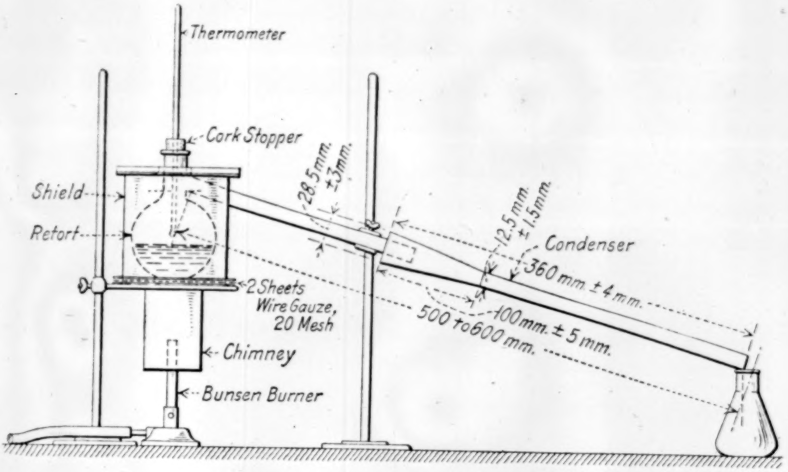

FIG. 2.—Apparatus Assembly.

2. That the Tentative Methods of Chemical Analysis of Zinc Chloride (D 199 - 24 T)[2] be advanced to standard.

3. That the Tentative Method of Test for Distillation of Creosote Oil (D 246 - 26 T)[3] be revised as follows:

Section 3. Condenser Tube.—Add to the table of requirements for dimensions of the condenser tube appearing in this section the following requirement on the length of the tapered portion:

"Length of tapered part.................... 100.00 mm. ± 5 mm."

Section 4.—Change from its present form: namely,

"An asbestos shield of the form and approximate dimensions shown in Fig. 2 shall be used to protect the retort from air currents and to prevent radiation. This may be covered with galvanized iron, as such an arrangement is more convenient and more permanent."

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 23, Part I, p. 771 (1923); also 1926 Book of A.S.T.M. Tentative Standards, p. 700.

[2] *Proceedings*, Am. Soc. Testing Mats., Vol. 24, Part I, p. 995 (1924); also 1926 Book of A.S.T.M. Tentative Standards, p. 707.

[3] *Proceedings*, Am. Soc. Testing Mats., Vol. 26, Part I, p.943 (1926); also 1926 Book of A.S.T.M. Tentative Standards, p. 702.

to read as follows:

"4. *Shield.*—A galvanized iron shield, lined with ⅛-in. asbestos, of the form and dimensions shown in Fig. 2 (the accompanying Fig. 1) shall be used to protect the flask from air currents and to prevent radiation. The cover (top) may be of transit board, galvanized iron lined with ⅛-in. asbestos, or of other suitable insulating material."

Figure 2.—Replace the present figure showing a cubical shield with a figure conforming to the accompanying Fig. 1, showing a cylindrical shield.

Figure 3.—Replace the present figure, illustrating the distillation apparatus assembly, with a figure conforming to the accompanying Fig. 2 in which a cylindrical shield is shown and also a tapered condenser tube.

No criticisms have been received regarding either of the two methods that are recommended for advancement to standard.

Respectfully submitted on behalf of the sub-committee,

S. R. CHURCH,
Chairman.

REPORT OF SUB-COMMITTEE IX ON METHODS OF TESTING

Sub-Committee IX unanimously recommends the advancement to Standard of the Tentative Methods of Testing Small Clear Specimens of Timber (D 143 - 24 T)[1] and the Tentative Methods for Conducting Static Tests of Timbers in Structural Sizes (D 198 - 24 T).[2] In this connection it may be mentioned that the Sectional Committee on Methods of Testing Wood, functioning under the rules of the American Engineering Standards Committee, with which Sub-Committee IX has been cooperating, is planning to recommend to the joint sponsors (the A.S.T.M. and U. S. Forest Service) that the two test procedures referred to be presented to the A.E.S.C. as American Standard.

The history of the development of the test procedure for small clear specimens of timber (Methods D 143 - 24 T) was discussed in the report of Committee D 7 for 1923.[3] The methods were accepted as tentative in 1922 and were revised in 1924. The revisions were of a very minor nature. They consisted of a few corrections and the addition of a preface and several explanatory footnotes, the latter tending to clarify the objective of certain requirements. The preface was suggested by Mr. Hogue and gives the background and scope of the methods.

No comments or criticisms have been received since the revision of 1924. In fact, but few were received prior to that date, most of the changes having originated with the committee.

The Methods for Conducting Static Tests of Timbers in Structural Sizes (D 198 - 24 T) were accepted as tentative in 1924. The preface states clearly the scope of the methods and gives the background surrounding their development. The intervening period has given ample time for the receipt of comments or criticisms, but none have been forthcoming. The committee is therefore pleased to recommend the advancement of Methods D 198 - 24 T to standard without change.

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 24, Part I, p. 939 (1924); also 1926 Book of A.S.T.M. Tentative Standards, p. 644.

[2] *Proceedings*, Am. Soc. Testing Mats., Vol. 24, Part I, p. 976 (1924); also 1926 Book of A.S.T.M. Tentative Standards, p. 681.

[3] *Proceedings*, Am. Soc. Testing Mats., Vol. 23, Part I, p. 418 (1923).

The preparation of these methods completes the immediate work before the sub-committee. No other projects are in prospect, but the sub-committee should be continued pending the need of developing tests for properties on which data are not now obtained and for which no definite procedure has been established.

Respectfully submitted on behalf of the sub-committee,

L. J. MARKWARDT,
Chairman.

REPORT OF SUB-COMMITTEE XI ON MOISTURE DETERMINATION

The Sub-Committee on Moisture Determination was organized in 1926 with instructions to consider methods for making moisture determinations which would be applicable to timber. The specific work of the committee was the preparation of standards for two types of moisture determinations:

1. A standard for an accurate method for use in the laboratory;
2. A standard for a method which would be sufficiently accurate and practical for field use.

The sub-committee held a meeting on November 4, 1926, at the Forest Products Laboratory, Madison, Wis., to consider work under way on moisture determinations by its staff. The work was explained in detail to the members of the committee. The committee did not feel, however, that it would be in a position to suggest tentative methods at the 1927 meeting of the Society.

The following is a brief outline of the work being carried out at the Forrest Products Laboratory:

Accurate Laboratory Methods:

A study has been made during the past year of three methods of determining moisture content for laboratory use, namely, oven drying, oven drying in a vacuum, and distillation.

Oven Drying.—Oven drying is the most commonly used method at the present time for determining the moisture in wood. The drying is carried out at 105° C. until constant weight is reached. This method when applied to wood has several inaccuracies caused by: (1) Atmospheric humidity in the room where the oven is located; (2) fluctuations in oven temperature; (3) the loss of volatile constituents of the wood which are distilled off and considered as water in the calculations.

Oven Drying Under a Vacuum.—Drying under a vacuum is subject to the same inaccuracies as the method just discussed and is slower in reaching a constant weight. It appears that the heat is retarded in reaching the wood and does not dry it out very rapidly.

Distillation Methods.—Work on the distillation methods has yielded rather interesting results. Six different materials, ether, benzine, toluene, xylene, turpentine and eucalyptus oil were used, each having different boiling points. The amount of moisture distilled off in these media increased with the boiling temperature when sawdust was used. Two samples of different moisture content indicated a constant variation in moisture when distilled at the boiling points of the various media.

The media used for moisture distillation are exceedingly inflammable and could not be used outside of the laboratory without serious danger. Some experiments have been conducted by collecting the moisture distilled off from individual specimens in small compartments. The heat is supplied by a temperature-regulated oven and the condensed moisture collected outside of the oven in a measuring tube. This method appears to offer some rather interesting possibilities. It is certain that accurate temperature regulation will be necessary for accurate results.

Practical Field Methods:

Electrical Methods.—An instrument known as the "megger," which is commonly used for measuring the leakage of current through insulation, was considered and a number of conductivity experiments carried out. The current is generated by hand, and the electrical conductivity is measured by means of a galvanometer.

This apparatus can only be used where the moisture content is uniformly distributed and when there are no wet streaks or wet surfaces present. It does not indicate moisture content above the fiber saturation point. It is subject to some error in making terminal contact with the lumber. Its use as a method of moisture determination will be restricted. The apparatus is quite expensive.

A new and very novel apparatus making use of radio frequency is under consideration. No direct contact with the board to be examined is necessary, and readings can be obtained in a few seconds. It indicates moisture content above the fiber saturation point as well as below. It is subject to error because of variations in density of wood. It is possible that this defect may be eliminated.

Hygroscopic Indicators.—Two general types have been considered. An instrument known as the duff hygrometer was developed at the Forest Products Laboratory to indicate the moisture content of forest duff or ground litter in the forest. This instrument is affected by the humidity in the interstices of the duff and reflects indirectly the existing moisture content on a dial by means of the shrinking and swelling of a reed. It was thought that this principle might be used for the measurement of moisture by inserting a suitable instrument in a drilled hole in the wood to be tested. Work on this was not completed in view of the conception of a more practical instrument.

A newer instrument consists of a capillary tube to which is attached a bulb of a very thin membrane sensitive to moisture and filled with mercury. A metal framework is provided to hold the scale and give mechanical protection. Changes in humidity surrounding the bulb of the instrument cause the membrane to shrink or swell, forcing the mercury to rise or fall in the capillary tube. The instrument is calibrated and used by drilling a hole in the lumber to be tested and inserting the base to the depth required. A reading may be obtained in about 10 minutes. Readings from 0 to 15 per cent are quite accurate and the divisions on the scale large. An accuracy of ± 1 per cent is probable with the instrument. Fluctuations of temperature amounting to 15 or 20° F. will not affect the readings appreciably. For greater changes some correction may be necessary. The instrument indicates the moisture content at the point where the hole is drilled and of the entire piece if the moisture at that point is representative of the moisture in the entire piece. The durability of the calibration is unknown at this time. Hair hygrometers are known to change in calibration with time, and it is possible that the instrument in question may also change. The instrument has the advantage of simplicity, is inexpensive, and is portable.

Respectfully submitted on behalf of the sub-committee,

M. E. DUNLAP,
Chairman.

REPORT OF COMMITTEE D-8

ON

BITUMINOUS WATERPROOFING AND ROOFING MATERIALS

Committee D-8 has held three meetings during the past year. One new method of test has been prepared for recommendation to the Society and one standard specification and one tentative specification have been slightly revised. Nine tentative specifications and three tentative methods of test are recommended for advancement to standard.

PROPOSED WITHDRAWAL OF EXISTING TENTATIVE SPECIFICATIONS AND METHOD OF TEST

After a great deal of work on the part of the Sub-Committee on Specifications for Bituminous Coatings for Cold Application and a careful investigation of the demand for specifications for such products, Committee D-8 has come to the conclusion that at the present time it is inadvisable to continue its efforts along this line and upon its own suggestion the sub-committee has been discharged.

In its last annual report as originally prepared, Committee D-8 presented eight tentative specifications and two tentative methods of test for materials for cold application, but owing to serious criticisms received finally recommended only two of these specifications and one method of test for acceptance by the Society. Since then it has become increasingly evident that most cold application materials are sold in small packages to consumers who are not interested in detailed specifications. These products are in general satisfactory for the purpose intended but vary so widely in composition as to make it impracticable to prepare acceptable standard specifications which will not describe some existing trade products and eliminate others equally as satisfactory.

For these reasons Committee D-8 recommends the withdrawal of the following tentative specifications which were accepted by the Society in 1926:

1. Tentative Specifications for Light Body Coal-Tar or Water-Gas-Tar Protective Coating with Solvent Vehicle, for Cold Application, for Damp-Proofing Masonry Structures (D 253 - 26 T);[1]
2. Tentative Specifications for Heavy Body Coal-Tar or Water-Gas-Tar Protective Coating with Solvent Vehicle, for Cold Application, for Damp-Proofing Masonry Structures (D 254 - 26 T).[2]

PROPOSED REVISION OF EXISTING STANDARD SPECIFICATIONS

Standard Specifications for Woven Cotton Fabrics Saturated with Bituminous Substances for Use in Waterproofing (D 173 - 25)[3].—The attention of the committee has been called to the fact that in these specifications no indication is given of allowance for sizing present in all commercial cotton fabrics. The following revision in this standard is accordingly recommended:

Section 4 (c).—To this section, reading as follows, add a footnote as indicated.

"(c) The fabric shall be composed of not less than 100 per cent[a] of cotton fibers."

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[a] This shall not exclude the presence of the customary sizing materials in amounts not exceeding 8 per cent by weight of the moisture-free cotton.

It is recommended that this revision be incorporated in the present standard specifications without publication as tentative. The committee accordingly asks for the necessary nine-tenths vote for the adoption of this revision as standard immediately.

PROPOSED REVISION AND ADVANCEMENT TO STANDARD OF EXISTING TENTATIVE SPECIFICATIONS

Tentative Specifications for Asphalt-Saturated Asbestos Felt for Use in Constructing Built-Up Roofs (D 250 - 26 T).[4]—Because the requirements are believed to be unnecessary it is recommended that the following sections be deleted from these specifications, renumbering the succeeding sections accordingly:

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 26, Part I, p. 979 (1926); also 1926 Book of A.S.T.M. Tentative Standards, p. 759.

[2] *Proceedings*, Am. Soc. Testing Mats., Vol. 26, Part I, p. 981 (1926); also 1926 Book of A.S.T.M. Tentative Standards, p. 761.

[3] A.S.T.M. Standards Adopted in 1925.

[4] *Proceedings*, Am. Soc. Testing Mats., Vol. 26, Part I, p. 972 (1926); also 1926 Book of A.S.T.M. Tentative Standards, p. 752.

Section 7 (g).—Average Breaking Strength.—With the fiber grain 25 lb., across the fiber grain 13 lb.

Section 8 (b).—The thickness of Desaturated Felt.—Minimum, 0.020 in.

It is recommended that these specifications as revised be advanced to standard.

PROPOSED ADVANCEMENT TO STANDARD OF EXISTING TENTATIVE SPECIFICATIONS AND METHODS OF TEST

No serious criticisms having been received on the following tentative specifications and methods of test, the committee recommends that they be advanced to standard:

1. Specifications for Asphalt Roll-Roofing Surfaced with Powdered Talc (D 224 - 26 T);[1]
2. Specifications for Slate-Surfaced Asphalt Roll-Roofing and Slate-Surfaced Asphalt Shingles (D 225 - 26 T);[1]
3. Specifications for Asphalt Roll-Roofing Surfaced with Granular Talc (D 248 - 26 T);[1]
4. Specifications for Heavy Weight Slate-Surfaced Asphalt Roll-Roofing and Heavy Weight Slate-Surfaced Asphalt Shingles (D 249 - 26 T);[1]
5. Specifications for Asphalt-Saturated Roofing Felt for Use in Waterproofing and in Constructing Built-Up Roofs (D 226 - 26 T);[1]
6. Specifications for Coal-Tar Saturated Roofing Felt for Use in Waterproofing and in Constructing Built-Up Roofs (D 227 - 26 T);[1]
7. Specifications for High-Carbon Coal-Tar Pitch for Use in Constructing Built-Up Roofs Surfaced with Slag or Gravel (D 251 - 26 T);[1]
8. Specifications for High-Bitumen Coal-Tar Pitch For Use in Constructing Built-Up Roofs Surfaced with Slag or Gravel (D 252 - 26 T);[1]
9. Methods of Testing Felted or Woven Fabrics Saturated with Bituminous Substances for Use in Waterproofing and Roofing (D 146 - 26 T);[1]
10. Methods of Testing Bituminous Mastics, Grouts and Like Mixtures (D 147 - 25 T);[2]
11. Methods of Testing Asphalt Roll-Roofing Surfaced with Fine or Granular Talc, Slate-Surfaced Asphalt Roll Roofing and Slate-Surfaced Asphalt Shingles (D 228 - 26 T).[1]

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 26, Part I, pp. 948–971, 975–978 and 983–997 (1926); also 1926 Book of A.S.T.M. Tentative Standards, pp. 728–751, 755–758, 763 and 778.

[2] *Proceedings*, Am. Soc. Testing Mats., Vol. 25, Part I, p. 786 (1925); also 1926 Book of A.S.T.M. Tentative Standards, p. 772.

NEW METHOD OF TEST SUBMITTED AS TENTATIVE

In its 1926 report, the committee recommended that the method of determining fiber composition appearing as Section 23 of Tentative Methods D 146 - 25 T be eliminated because it was not sufficiently accurate. A new sub-committee was appointed to prepare a satisfactory method for this determination and during the past year this sub-committee has developed the new method appended hereto[1] entitled Tentative Methods of Analysis of Roofing Felt for Fiber Composition, which the committee recommends for publication as tentative.

TABLE I.—ANALYSIS OF LETTER BALLOT VOTE.

Items	Affirmative	Negative	Not Voting
I. PROPOSED REVISION OF EXISTING STANDARD			
Standard Specifications for Woven Cotton Fabrics Saturated with Bituminous Substances for Use in Waterproofing (D 173 - 25)	35	0	15
II. PROPOSED ADVANCEMENT OF TENTATIVE SPECIFICATIONS AND METHODS OF TEST TO STANDARD			
Tentative Specifications for Asphalt-Saturated Asbestos Felt for Use in Constructing Built-Up Roofs (D 250 - 26 T) as revised	38	2	10
Tentative Specifications for Asphalt Roll-Roofing Surfaced with Powdered Talc (D 224 - 26 T)	38	2	10
Tentative Specifications for Slate-Surfaced Asphalt Roll-Roofing and Slate-Surfaced Asphalt Shingles (D 225 - 26 T)	38	2	10
Tentative Specifications for Asphalt Roll-Roofing Surfaced with Granular Talc (D 248 - 26 T)	38	2	10
Tentative Specifications for Heavy Weight Slate-Surfaced Asphalt Roll-Roofing and Heavy Weight Slate-Surfaced Asphalt Shingles (D 249 - 26 T)	37	2	11
Tentative Specifications for Asphalt-Saturated Roofing Felt for Use in Waterproofing and in Constructing Built-Up Roofs (D 226 - 26 T)	38	1	11
Tentative Specifications for Coal-Tar Saturated Roofing Felt for Use in Waterproofing and in Constructing Built-Up Roofs (D 227 - 26 T)	35	2	13
Tentative Specifications for High-Carbon Coal-Tar Pitch for Use in Constructing Built-Up Roofs Surfaced with Slag or Gravel (D 251 - 26 T)	35	1	14
Tentative Specifications for High-Bitumen Coal-Tar Pitch for Use in Constructing Built-Up Roofs Surfaced with Slag or Gravel (D 252 - 26 T)	34	2	14
Tentative Methods of Testing Felted or Woven Fabrics Saturated with Bituminous Substances for Use in Waterproofing and Roofing (D 146 - 26 T)	36	2	12
Tentative Methods of Testing Bituminous Mastics, Grouts and Like Mixtures (D 147 - 25 T)	39	0	11
Tentative Methods of Testing Asphalt Roll-Roofing Surfaced with Fine or Granular Talc, Slate-Surfaced Asphalt Roll-Roofing and Slate-Surfaced Asphalt Shingles (D 228 - 26 T)	38	3	9
III. PROPOSED NEW TENTATIVE STANDARD			
Tentative Methods of Analysis of Roofing Felt for Fiber Composition	39	0	11
IV. PROPOSED WITHDRAWAL OF EXISTING TENTATIVE SPECIFICATIONS AND METHODS OF TEST			
Tentative Specifications for Light Body Coal-Tar or Water-Gas-Tar Protective Coating with Solvent Vehicle, for Cold Application, for Damp-Proofing Masonry Structures (D 253 - 26 T)	40	0	10
Tentative Specifications for Heavy Body Coal-Tar or Water-Gas-Tar Protective Coating with Solvent Vehicle, for Cold Application, for Damp-Proofing Masonry Structures (D 254 - 26 T)	40	0	10

The results of collaborative work on this new method by a number of laboratories is published as an appendix to this report as it is believed that they will be of considerable value to all who are interested in the method and establish a basis for the committee's recommendation.

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[1] See p. 968.—ED.

The results of letter ballot of the committee upon the recommendations made in this report appear in Table I.

This report has been submitted to letter ballot of the committee, which consists of 50 members, of whom 38 have voted affirmatively, none negatively, and 12 have refrained from voting.

Respectfully submitted on behalf of the committee,

S. T. WAGNER,
Chairman.

PRÉVOST HUBBARD,
Secretary.

EDITORIAL NOTE

The proposed revisions of the Standard Specifications for Woven Cotton Fabrics Saturated with Bituminous Substances for Use in Waterproofing were approved at the annual meeting by a nine-tenths vote and were subsequently adopted by letter ballot of the Society on September 1, 1927. The specifications as revised appear in the 1927 Book of A.S.T.M. Standards, Part II.

The following tentative specifications and methods were approved at the annual meeting and subsequently adopted by letter ballot of the Society on September 1, 1927: for Asphalt-Saturated Asbestos Felt for Use in Constructing Built-Up Roofs, revised as recommended by the committee; for Asphalt Roll-Roofing Surfaced with Powdered Talc; for Slate-Surfaced Asphalt Roll-Roofing and Slate-Surfaced Asphalt Shingles; for Asphalt Roll-Roofing Surfaced with Granular Talc; for Heavy Weight Slate-Surfaced Asphalt Roll-Roofing and Heavy Weight Slate-Surfaced Asphalt Shingles; for Asphalt-Saturated Roofing Felt for Use in Waterproofing and in Constructing Built-Up Roofs; for Coal-Tar Saturated Roofing Felt for Use in Waterproofing and in Constructing Built-Up Roofs; for High-Carbon Coal-Tar Pitch for Use in Constructing Built-Up Roofs Surfaced with Slag or Gravel; for High-Bitumen Coal-Tar Pitch for Use in Constructing Built-Up Roofs Surfaced with Slag or Gravel; Methods of Testing Felted or Woven Fabrics Saturated with Bituminous Substances for Use in Waterproofing and Roofing; of Testing Bituminous Mastics, Grouts and Like Mixtures; and of Testing Asphalt Roll-Roofing Surfaced with Fine or Granular Talc, Slate-Surfaced Asphalt Roll-Roofing and Slate-Surfaced Asphalt Shingles. The specifications and methods appear in the 1927 Book of A.S.T.M. Standards, Part I.

The Tentative Specifications for Light Body Coal-Tar or Water-Gas-Tar Protective Coating with Solvent Vehicle, for Cold Application, for Damp-Proofing Masonry Structures; and for Heavy Body Coal-Tar or Water-Gas-Tar Protective Coating with Solvent Vehicle, for Cold Application, for Damp-Proofing Masonry Structures, were withdrawn.

The proposed Tentative Methods of Analysis of Roofing Felt for Fiber Composition were accepted for publication as tentative and appear on page 968.

APPENDIX

REPORT OF SPECIAL SUB-COMMITTEE ON COOPERATIVE TESTS ON ANALYSIS OF ROOFING FELT FOR FIBER COMPOSITION

Four average samples of roofing felt were sent by the U. S. Bureau of Standards to a number of laboratories of members of Committee D-8 who signified their desire to participate in the cooperative tests to determine the fiber composition of roofing felts. The samples of felt were made at the Bureau for another purpose and in a very rough way their composition was known.

Eleven sets of results using the dot method of counting prescribed in the proposed Tentative Methods of Analysis of Roofing Felt for Fiber Composition[1] have been received. Two laboratories reported results by the old estimation method. One laboratory made no separation of mechanical wood, jute and manila and its results have been omitted. Two laboratories have not yet reported although they advise that the work is in progress.

TABLE I.—RESULTS REPORTED BY LABORATORIES USING THE DOT METHOD.

SAMPLE A

	SUPPOSED COMPOSITION	AVERAGE FOUND	WEIGHTED AVERAGE FOUND
Rag, per cent	10	12.5	10.3
Mixed papers and sawdust, per cent	30	37.1	36.7
Bagging, per cent	60	49.9	53.0

Laboratory	Wool, per cent	Cotton, Linen, etc., per cent	Chemical Wood, per cent	Mechanical Wood, per cent	Jute, Manila, per cent	Unidentified Fibers, per cent
A-1	0	8	11	13	68*	0
A-2	trace	10	10	12	68*	0
B	0.6	10.7	15.2	23.5*	49.0	1.0
C	1.6	7.5	24.3	14.0	50.8	1.8
D	5.0*	10.0	25.0	15.0	45.0	0
E	1.0	10.0	17.0	21.0*	51.0	0
F	6.1*	10.3	19.2	10.0	54.4	0
G-1	14.0*	15.0*	24.0	13.0	32.0*	2.0
G-2	0	10.0	25.0	15.0	50.0	0
H	0	9.0	32.0*	28.0*	31.0*	0
I	trace	10.0	16.0	25.0*	49.0	0
Average of All Results	2.5	10.0	19.9	17.2	49.9	0.5
Weighted Average	0.3	10.0	22.9	13.8	53.0	0
Variation in Accepted Results	0 – 1.6	7.5 – 10.7	10 – 25.0	12 – 15	45.0 – 54.4	
Maximum Variation from Average	±1.1	±2.7	±11.1	±2.2	±9.0	

An asterisk (*) indicates that the value has been omitted in the weighted average.

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[1] See p. 968.

TABLE I.—RESULTS REPORTED BY LABORATORIES USING THE DOT METHOD—(*Continued*).

SAMPLE B

	SUPPOSED COMPOSITION	AVERAGE FOUND	WEIGHTED AVERAGE FOUND
Rag, per cent	50	44.8	47.2
Mixed papers and sawdust, per cent	50	48.1	50.1
Bagging, per cent	..	6.5	2.7

Laboratory	Wool, per cent	Cotton, Linen, etc., per cent	Chemical Wood, per cent	Mechanical Wood, per cent	Jute, Manila, per cent	Unidentified Fibers, per cent
A-1	3.0	42.0	15.0*	40.0*	trace	0
A-2	trace*	45.0	20.0	30.0	4.0	0
B	3.7	42.6	18.6	30.8	2.3	2.0
C	3.1	23.3*	39.1*	24.0	7.2*	3.3
D	10.0*	35.0*	20.0	25.0	10.0*	0
E	4.0	43.0	20.0	30.0	3.0	0
F	3.6	44.5	24.5	10.1*	17.3*	0
G-1	6.0	40.0	25.0	8.0*	20.0*	1.0
G-2	0*	51.0*	25.0	24.0	0	0
H	0*	44.0	23.0	30.0	3.0	0
I	trace*	49.0*	27.0*	20.0*	4.0	0
Average of All Results	3.0	41.8	23.4	24.7	6.5	0.6
Weighted Average	3.9	43.3	22.2	27.9	2.7	
Variation in Accepted Results	3.0 - 6.0	40 - 45	18.6 - 25.0	24 - 30.8	0 - 4	
Maximum Variation from Average	±2	±3.5	±3.8	±4.1	±2	

SAMPLE C

	SUPPOSED COMPOSITION	AVERAGE FOUND	WEIGHTED AVERAGE FOUND
Rag, per cent	60	46.8	50.8
Mixed papers and sawdust, per cent	25	34.0	31.7
Bagging, per cent	15	19.8	17.5

Laboratory	Wool, per cent	Cotton, Linen, etc., per cent	Chemical Wood, per cent	Mechanical Wood, per cent	Jute, Manila, per cent	Unidentified Fibers, per cent
A-1	trace*	51.0	11.0	23.0	15.0	0
A-2	5.0	50.0	6.0*	16.0	23.0	0
B	6.6	52.7	9.0	19.0	11.3*	1.4
C	3.8	46.8	15.3	16.1	15.3	2.7
D	0*	25.0*	15.0	40.0*	20.0	0
E	5.0	40.0	14.0	24.0	17.0	0
F	0*	41.9	19.5*	15.1	23.5	0
G-1	7.0	42.0	22.0*	2.0*	27.0*	0
G-2	0*	50.0	14.0	16.0	20.0	0
H	0*	41.0	16.0	26.0	17.0	0
I	0*	46.0	12.0	23.0	19.0	0
Average of All Results	2.5	44.3	14.0	20.0	19.8	0.4
Weighted Average	5.3	45.5	12.7	19.0	17.5	
Variation in Accepted Results	3.8 - 7.0	40.0 - 52.7	9.0 - 16.0	15.1 - 26.0	15.0 - 23 5	
Maximum Variation from Average	±2	±7.9	±4.0	±7.2	±5.1	

An asterisk (*) indicates that the value has been omitted in the weighted average.

TABLE I.—RESULTS REPORTED BY LABORATORIES USING THE DOT METHOD—(*Continued*).

SAMPLE D

	SUPPOSED COMPOSITION	AVERAGE FOUND	WEIGHTED AVERAGE FOUND
Rag, per cent	10	11.8	10.3
Mixed papers and sawdust, per cent	90	75.4	86.3
Bagging, per cent	0	12.5	3.4

Laboratory	Wool, per cent	Cotton, Linen, etc., per cent	Chemical Wood, per cent	Mechanical Wood, per cent	Jute, Manila, per cent	Unidentified Fibers, per cent
A-1	0	8.0	26.0*	66.0*	0	0
A-2	1.0	14.0	29.0	58.0	0	0
B	0.9	7.3	39.3	35.5	15.0*	1.8
C	0.8	5.2	46.9*	34.2	11.0	1.9
D	0	25.0*	0*	25.0*	50.0*	0
E	1.0	7.0	30.0	61.0	1.0	0
F	8.9*	10.5	34.7	27.7*	18.2*	0
G-1	1.0	12.0	40.0	15.0*	32.0*	0
G-2	0	12.0	37.0	40.0	11.0	0
H	0	7.0	34.0	59.0	0	0
I	0	9.0	36.0	55.0	trace	0
Average of All Results	1.1	10.7	32.1	43.3	12.5	0.3
Weighted Average	0.3	10.0	33.5	52.8	3.4	
Variation in Accepted Results	0 - 1.0	5.2 - 14.0	29.0 - 40.0	34.2 - 61.0	0 - 11.0	
Maximum Variation from Average	±0.6	±5.0	±6.5	±18.3	±6.6	

An asterisk (*) indicates that the value has been omitted in the weighted average.

Table I gives results on each sample as reported by the eleven laboratories using the dot method, showing first the results of all tests reported, then an average of all results received, and finally a weighted average in which all figures against which an asterisk appears have been omitted. In the case of each felt a comparison is given of the supposed composition with the general average and the weighted average.

For the sake of completeness the two results received on the estimation method are also included and appear in Table II.

TABLE II.—RESULTS REPORTED BY LABORATORIES USING THE ESTIMATION METHOD.

Material	Sample A		Sample B		Sample C		Sample D	
	Laboratory J	Laboratory K	Laboratory J	Laboratory K	Laboratory J	Laboratory K	Laboratory J	Laboratory K
Wool, per cent	0	0	5.0	0	5.0	0	0	0
Cotton, linen, etc., per cent	10	0	45.0	50.0	60	70	10	0
Chemical wood, per cent	15	13	15	15	5	2	20	25
Mechanical wood, per cent	30	30	35	25	15	15	70	65
Jute and Manila, per cent	45	57	0	10	15	13	0	10

Comments:

The chairman of the special sub-committee has reviewed the results and believes that the correspondence of the weighted averages with the supposed compositions justifies the selection of results.

It seems reasonable that the differences in results obtained are to a considerable extent due to inexperience in the recognition of fibers. Of the 60 rejected figures out of a total of 220, 21 are from two sets of determinations while 40 are from 5 sets. The other 6 laboratories are in general reasonably concordant throughout, that is, A-2, B, C, E, G-2 and I (A-1 and 2 and G-1 and 2 represent two different laboratories of a single organization). Some of the differences are of course due to sampling which is very difficult in materials of this type. The variations in general, however, are materially less in the accepted results than has been experienced with the methods generally used in the past. Further cooperative tests are to be carried out to perfect the technique of operation and it is hoped that considerably greater concordance can be obtained than was done in this preliminary set of results.

Respectfully submitted on behalf of the committee,

J. M. WEISS, *Chairman.*
H. ABRAHAM
C. E. LIBBY
O. G. STRIETER

REPORT OF COMMITTEE D-9
ON
ELECTRICAL INSULATING MATERIALS

The committee held three meetings during the year as follows, each for two days, in addition to the meeting held during this annual meeting of the Society:

At Bell Telephone Laboratories, New York City, October 28–29, 1926;

At Edison Electric Illuminating Co., Boston, Mass., January 27–28, 1927;

At Bellevue-Stratford Hotel, Philadelphia, Pa., March 17–18, 1927.

In addition to the above meetings of the main committee and its sub-committees, the various sub-committees have held additional meetings in order to promote their work. Sub-Committees II on Molded Insulating Materials and VII on Radio Frequency Tests have been particularly active in this regard.

The activities of the committee continue to be devoted to the development and standardization of methods of testing.

EXISTING STANDARDS AND TENTATIVE STANDARDS

The committee recommends the following action with respect to existing standards and tentative standards:

Standard Methods of Testing Molded Insulating Materials (*D 48 – 24*).[1]—Two years ago the committee recommended a number of revisions in this standard which were accepted for publication as tentative revisions. Last year an additional minor revision was added. It is recommended that the tentative revisions[2] be advanced to standard with the exception of the proposed revision of Section 3. This revision should be deleted.

The committee has also been working for some time on a new dielectric strength specimen to replace the cup now in use. A disk has been found more satisfactory for this purpose not only from the standpoint of dielectric strength, but also as a means of judging the moldability of the material, which was an important reason for the adoption of the cup specimen. The committee, therefore, recommends the following revision of Methods D 48 – 24 for publication as tentative:

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[1] 1924 Book of A.S.T.M. Standards.

[2] See *Proceedings*, Am. Soc. Testing Mats., Vol. 26, Part I, p. 1136 (1926); also 1926 Book of A.S.T.M. Tentative Standards, p. 1038.

Section 15.—Change from its present form: namely,

"The test specimen shall be molded to the dimensions shown in Fig. 4. The mold shall be hardened and ground to these dimensions. If the material cannot be molded to the full height shown, the height may be reduced to $1\frac{1}{4}$ in. (31.7 mm.).

"For materials having a puncture value higher than 300 volts per mil, the thickness of the bottom of the specimen may be reduced to 0.098 in. (2.5 mm.). It should be noted, however, that the apparent dielectric strength in volts per mil may be increased as much as 50 per cent when the thickness of the bottom of the specimen is so reduced."

to read as follows:

"The test specimen shall be molded in the form of a disk 4 in. (10.16 cm.) in diameter which should be $\frac{1}{8}$ in. (3.175 mm.) in thickness for hot molded materials and $\frac{1}{4}$ in. (6.35 mm.) in thickness for cold molded materials."

Section 16.—Change Paragraph (*a*) from its present form: namely,

"(*a*) Voltage shall be applied to the test specimen by floating the specimen on mercury and placing a pool of mercury about $\frac{1}{8}$ in. (3 mm.) deep inside the specimen.

"It is recommended that all tests be made in air, but whenever it is impossible to puncture the specimen in air without arcing over the edge, it shall be immersed in high grade transformer oil. On specimens which require a very high voltage to puncture, it may be necessary to put a glass tube or shield over the wire leading to the mercury on the inside of the specimen in order to prevent breakdown over the surface of the oil between terminals. The testing voltage shall be raised at a constant rate of approximately one thousand volts per second until puncture occurs."

to read as follows:

"Voltage shall be applied to the test specimen by means of two flat electrodes 1 in. in diameter with edges rounded to a radius of $\frac{1}{8}$ in. These electrodes shall be placed directly opposite each other at the center of the specimen.

"It is recommended that all tests on hot molded materials be made under oil and tests on cold molded materials in air. Testing voltage shall be raised at a constant rate of approximately 1000 volts per second until a puncture occurs."

Omit Paragraph (*c*) reading as follows:

"(*c*) The results from specimens where puncture takes place up on the side of the specimen instead of through the bottom shall be discarded. Experience shows that very plastic materials which flow easily in the mold always puncture through the bottom, while materials which do not mold readily will often puncture through the side walls of the specimen at some distance up from the bottom."

Section 17 (a).—Change from its present form: namely,

> "The thickness of the bottom of each specimen measured with a micrometer in the direction perpendicular to the bottom surface, and also the thickness at the point of puncture, regardless of the path taken by the discharge. The thickness of each specimen shall be given in mils or in millimeters."

to read as follows:

> "The thickness of each specimen shall be given in mils or millimeters."

Figure 4.—Omit this figure.

In the Methods of Testing Molded Insulating Materials (D 48 – 24), statements relative to the dimensions of the test specimens are not uniform in that in some cases the dimensions given refer to the specimen and in other cases to the mold. It was the intent of the committee that the dimensions given should in all cases refer to the test specimen. It is therefore recommended that such minor changes in wording in the methods as now printed be made as may be required to conform to this intent.

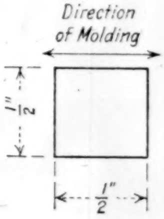

Fig. 1.

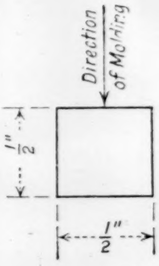

Fig. 2.

Tentative Methods of Testing Insulating Materials for Resistance to Impact (D 256 – 26 T).[1]—In the illustration in Figs. 1 and 2, which shows the direction of molding relative to the direction of notch in the specimen, the arrows indicating these directions are incorrectly placed. As they are shown, the molding is practically impossible. It is therefore recommended that the direction of molding be represented correctly and that in both Figs. 1 and 2, the present illustration shown in the accompanying Fig. 1 be changed to conform to the accompanying Fig. 2.

It is recommended that, with the above changes, the methods be continued as tentative.

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 26, Part I, p. 1056 (1926); also 1926 Book of A.S.T.M. Tentative Standards, p. 877.

Tentative Methods of Testing Untreated Insulating Paper (D 202 - 26 T).[1]—The following revisions are recommended:

Section 34.—Change the second sentence from its present form: namely,

> "Ethylene glycol shall be placed in it to a depth of 12.7 cm. (5 in.)."

to read as follows:

> "A lubricating oil with viscosity of 60 to 70 seconds Saybolt at 37.8° C. (100° F.) shall be placed in it to a depth of 12.7 cm. (5 in.)."

Change the words "Ethylene glycol" at the beginning of the third paragraph of the note to Section 34, to the word "oil."

Add a fourth paragraph to the note to Section 34 to read as follows:

> "Precautions should be taken to avoid subjecting the apparatus to vibration as this condition would increase the rate of air displacement."

It is recommended that the method as revised be continued as tentative.

Tentative Methods of Testing Sheet and Tape Insulating Materials for Dielectric Strength (D 149 - 26 T).[2]—The following revisions are recommended:

Section 1.—Change the first sentence from its present form: namely,

> "These methods are designed to determine the dielectric strength of sheet and tape insulating materials."

to read as follows:

> "These methods are designed to determine the dielectric strength of sheet and tape insulating materials except (*a*) rubber insulating tape, which should be tested in accordance with the Tentative Specifications for Rubber Insulating Tape (Serial Designation: D 119 - 22 T) of the American Society for Testing Materials,[3] and (*b*) adhesive tape for electrical purposes which should be tested in accordance with the Standard Specifications for Adhesive Tape for General Use for Electrical Purposes (Serial Designation: D 69) of the American Society for Testing Materials.[4]

Section 19.—Omit the word "even" before "1000 volts" at the beginning of the third line of Section 19.

It is recommended that the methods as revised be continued as tentative.

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 26, Part I, p. 1037 (1926); also 1926 Book of A.S.T.M. Tentative Standards, p. 858.

[2] *Proceedings*, Am. Soc. Testing Mats., Vol. 26, Part I, p. 1029 (1926); also 1926 Book of A.S.T.M. Tentative Standards, p. 820.

[3] *Proceedings*, Am. Soc. Testing Mats., Vol. 22, Part I, p. 934 (1922); also 1926 Book of A.S.T.M. Tentative Standards, p. 912.

[4] 1924 Book of A.S.T.M. Standards.

Tentative Methods of Testing Electrical Insulating Oils (*D 117 - 26 T*).[1]—Last year the committee recommended that this tentative standard be accepted to supersede the Standard Methods D 117 - 24.

The dimension of $\frac{1}{4}$ in. for the length of the legs of the thief as shown in Fig. 1 and Section 3 (*b*) of the methods should be changed to $\frac{1}{8}$ in.

Section 6 (*d*).—Change the first sentence to read as follows by the insertion of the italicized words:

> "Drums and barrels of oil to be sampled should be lined up *preferably on their sides* and numbered, bungs up."

Change the fourth sentence of Section 6 (*d*) so as to substitute the words "lowest part of the recess," for the word "bottom."

Section 17 (*a*).—Omit the words "(at least 50,000 kv.)" in parenthesis at the end of the second sentence.

The committee recommends that the tentative methods as revised be advanced to standard, superseding the present standard methods.

Tentative Methods of Testing Electrical Porcelain (*D 116 - 26 T*).[2]—It was stated in last year's report that a method for determining pore volume of porcelain, which permits of a quantitative determination, was being investigated. This method has now been written and the committee recommends that it be incorporated in the methods as a part of the determination of Porosity, the determination by Water Absorption being Method *A*, and the new determination by Pore Volume being Method *B*. This involves the addition of new Sections 38 to 43 to read as follows:

(*B*) *Pore Volume*

38. The pore volume of porcelain shall be determined by measuring (at atmospheric pressure) the volume of air contained in a sample of porcelain of known volume.

39. *Apparatus.*—Any suitable apparatus based on the laws of gas expansion, which will accomplish the measurement called for in Section 38 may be used.

The McLeod gage type of porosimeter is especially adaptable to this determination. This apparatus consists of a receptacle and cap fitted together by a ground air-tight joint. The cap is surmounted by a calibrated capillary tube and stop-cock. The specimen is placed in the receptacle and prevented from rising into the cap by means of a constriction or pin. The receptacle is connected by a glass or metal pipe at the bottom to a heavy rubber hose which in turn is connected to a glass leveling bulb. The total volume of the specimen receptacle and cap should be approximately 200 cc. Figure 7 (the accompanying Fig. 3) shows a diagrammatic sketch of a McLeod gage-type porosimeter.

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 26, Part I, p. 1021 (1926); also 1926 Book of A.S.T.M. Tentative Standards, p. 812.

[2] *Proceedings*, Am. Soc. Testing Mats., Vol. 26, Part I, p. 1010 (1926); also 1926 Book of A.S.T.M. Tentative Standards, p. 801.

NOTE.—Suitable porosimeters of the McLeod gage type are: (1) glass apparatus of Washburn and Bunting;[1] (2) metal apparatus of Navias.[2]

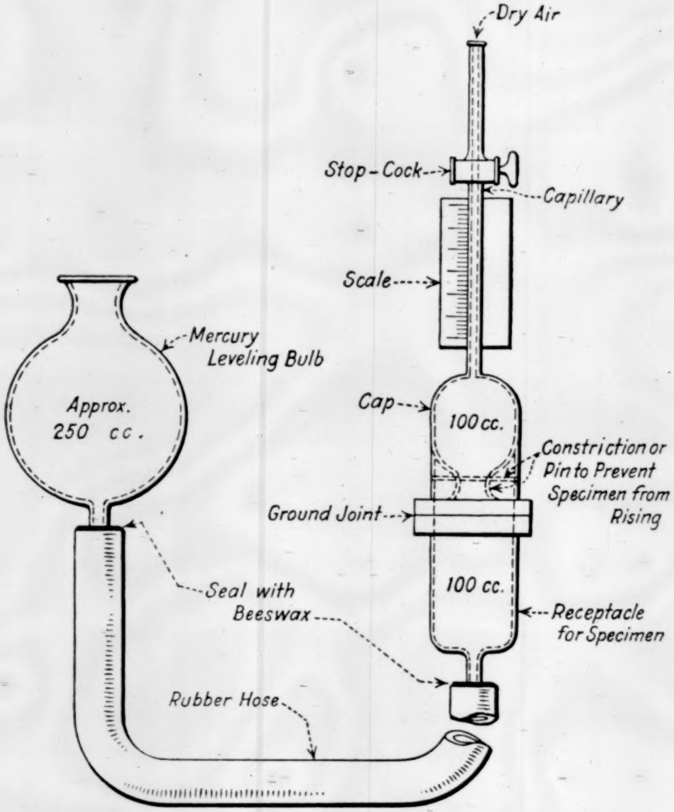
Dry Air
Stop-Cock
Capillary
Scale
Mercury Leveling Bulb
Approx. 250 cc.
Cap
100 cc.
Constriction or Pin to Prevent Specimen from Rising
Ground Joint
Seal with Beeswax
100 cc.
Receptacle for Specimen
Rubber Hose

FIG. 3.—Diagrammatic Sketch of Porosimeter.

Volume and Length of Capillary.—For porcelain of low-pore volume it is necessary to use a capillary of small diameter to read the volume of accumulated air accurately. Thus, for porcelain up to 1 per cent pore volume the effective volume of the capillary must be at least 0.5 cc. (for a specimen of 50 cc. volume). For porcelain having a higher pore volume than 1 per cent, either a longer capillary or a capillary of larger diameter is required.

Atmospheric Conditions.—It is essential that the determination be made using dry air. This may be provided by any suitable means.

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[1] Washburn and Bunting, *Journal*, Am. Ceramic Soc., Vol. 5, pp. 528–535 (1922).

[2] Navias, *Journal*, Am. Ceramic Soc., Vol. 8, pp. 816–821 (1925).

40. *Test Specimen.*—The test specimen shall consist of two or more pieces of porcelain having a total volume of not less than 50 cc. At least 50 per cent of the surface of the parts used shall be newly fractured.

41. *Procedure.*—(*a*) The following procedure is based on the use of a McLeod gage type of porosimeter:

(*b*) The fractured pieces of porcelain shall be placed in the receptacle, the ground joint greased, and the cap secured in position so that the apparatus is air-tight.

(*c*) Before making determinations, any moisture entrapped on the inner surface of the porosimeter or which may be on the test specimen shall be removesd. To do this, the leveling bulb shall be raised until the mercury in the capillary is above the stop-cock. The stop-cock shall then be closed and the leveling bulb lowered so that the test specimen is subjected to a vacuum for at least one minute. Any moisture inside the porosimeter then vaporizes and by again raising the leveling bulb the gas is collected in the capillary and shall be finally expelled by opening the stop-cock.

(*d*) Immediately after removing the moisture the leveling bulb shall be lowered, exposing the test specimen to the air for at least one minute. The leveling bulb shall again be raised until the mercury in the capillary is above the stop-cock. The stop-cock shall then be closed and the leveling bulb lowered so as to expose all the specimen to the vacuum for at least one minute. The air contained in the porcelain then expands into the evacuated space around and above the porcelain. The mercury bulb shall then be raised again and the air collected in the capillary tube. When the mercury surface in the leveling bulb is on a level with the mercury meniscus in the capillary the accumulated air in the capillary is at atmospheric pressure and its volume, v, shall be read. This shall be considered to be the pore volume.

(*e*) Several determinations of the pore volume should immediately be made as described in Paragraph (*d*). The values of pore volume thus obtained should be practically equal, and their average may be taken as the pore volume of the specimen, v. Lack of agreement among these values may be traced to leaks or moisture in the apparatus.

NOTE.—To test for leaks in the apparatus: After taking a reading, expel all gas from the apparatus. Close the stop-cock. Raise and lower the leveling bulb several times. The level of the mercury in the capillary should rise to the stop-cock when the leveling bulb is raised.

(*f*) The total volume V, of the pieces of each specimen shall be obtained by any suitable method, measuring to the nearest 0.2 cc.

(*g*) Not less than five specimens shall be tested.

42. *Percentage of Pore Volume.*—The percentage of pore volume shall be calculated as the volume of gas contained in the total volume of porcelain:

$$\text{Percentage of pore volume} = \frac{v \times 100}{V}$$

where V = total volume of test specimen as determined in Section 41 (*f*); and
v = the pore volume as determined in Sections 41 (*d*) and (*e*).

43. *Report.*—The report shall include the following:

(*a*) The percentage of pore volume of each specimen, the average of these values, and the percentage average deviation from the mean;
(*b*) The total volume of each test specimen;
(*c*) The name and type of the apparatus used;
(*d*) The total volume of the specimen receptacle.

Study of methods for determining dielectric strength has shown that it is possible to break down electrically disk specimens of porcelain 2 in. in diameter and thickness ranging up to 1.5 in. Comparative tests made in four different laboratories on specimens up to ¾ in. in thickness showed possible agreement to be in the order of 10 per cent. The committee therefore recommends that the present method for determining dielectric strength, comprising Sections 22 to 25, be deleted, and new Sections 22 to 25 given below, describing the new method, be inserted in their stead:

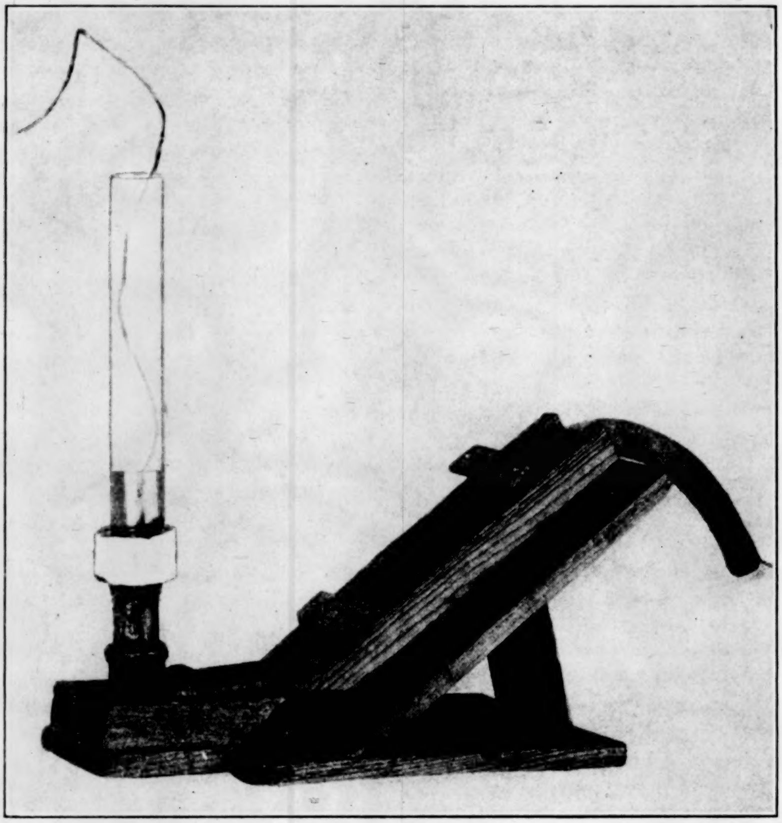

FIG. 4.—Suggested Means for Holding Porcelain Dielectric Strength Test Specimen.

DIELECTRIC STRENGTH

22. *Apparatus*.—The apparatus shall be as described in Section 14 of the Standard Methods of Testing Molded Insulating Materials (Serial Designation: D 48) of the American Society for Testing Materials.[1]

23. *Specimen*.—The specimen shall be a disk approximately 2 in. in diameter, the flat sides being made plane and parallel. The thickness of the specimen shall be 0.250 in. (6.35 mm.), 0.4 in. (10.16 mm.), 0.75 in. (19.05 mm.), or 1.0 in. (25.4 mm.). The thickness shall be within ± 10 per cent of these values.

NOTE.—The specimen tested should be of a thickness comparable to that of the finished porcelain product.

24. *Method*.—(*a*) The specimen shall be tested between metallic electrodes 0.75 in. (19.05 mm.) in diameter, placed exactly opposite each other.

NOTE.—A suggested means for holding the specimen, using mercury electrodes, is shown in Fig. 6 (the accompanying Fig 4). This consists of a metal tube supported in a frame. The specimen is affixed to the metal tube using ordinary sealing wax, and a short glass tube is similarly affixed to the upper surface of the specimen.

In applying the sealing wax, one end of the tube is dipped about $\frac{3}{8}$ in. (9.5 mm.) into a bath of molten wax. Upon removal, it is immediately pressed into place on the specimen and allowed to cool to room temperature. (If a film of wax covers the tube it should be broken before placing the tube on the specimen). In order more thoroughly to smooth out the wax and seal the tube, the wax seal may be softened slightly with a fine moderate flame. The test specimen should never be heated when affixing the tubes, as the heat may set up strains in the porcelain specimen that will materially affect its properties.

Mercury is introduced into both tubes, avoiding entrapped air, and lead wires are placed in the mercury. The entire set-up is immersed in high-grade mineral insulating oil. It is best to have the ends of the tubes projecting above the oil level.

(*b*) The testing voltage shall be raised at a constant rate of approximately 1000 volts per second until puncture occurs.

(*c*) Not less than five specimens shall be punctured in their normal condition at a normal room temperature of about 20° C. (68° F.).

25. *Report*.—The report shall include the following:

(*a*) The breakdown voltage for each specimen in kilovolts;

(*b*) The thickness of each specimen in mils at point of break;

(*c*) The dielectric strength in volts per mil calculated from the values reported in Paragraphs (*a*) and (*b*).

(*d*) The average breakdown voltage, the average thickness of the specimen at break, and the average dielectric strength in volts per mil for the specimens tested.

Tentative Methods of Testing Electrical Insulating Materials for Phase Difference (Power Factor) and Dielectric Constant at Radio Frequencies (D 150 - 23 T).[2]—As was stated in last year's report, considerable attention had been given to the study of methods for power factor measurement. The method has been tentative for three years, though as written it is not used in the industry to any extent to-day. The work mentioned has included the measurement of sixteen samples of dielectrics by five different laboratories using methods now in use by each respective laboratory. It has been shown that these measurements can be made with a maximum difference between laboratories of 15 per cent. This is considered reasonable for this type of measurement at the present state of the art.

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[1] 1924 Book of A.S.T.M. Standards.

[2] *Proceedings*, Am. Soc. Testing Mats., Vol. 23, Part I, p. 822 (1923); also 1926 Book of A.S T.M. Tentative Standards, p. 828.

There are at the present time two types of methods in general use: (1) the so-called "Substitution Method" and (2) the "Bridge Method." A method for determining power factor and dielectric constant of electrical insulating materials at frequencies of 100 to 1500 kilocycles has therefore been written incorporating both of these methods and is appended hereto.[1] It is recommended that the present Tentative Methods D 150 - 23 T be withdrawn and replaced by the proposed new tentative method.

MISCELLANEOUS

Insulating Varnishes:

In last year's report reference was made to a preliminary study being made to investigate methods of testing liquid varnish for dielectric strength. The subject has been active and a method has been written for cleaning the electrodes between shots. The samples are being circulated and comparative results will be obtained soon by different laboratories using the same method.

Considerable work has been done in connection with the determination of the drying time of varnishes. Two methods have been studied. The first was submitted by the General Electric Co. and involves the folding over of a paper which has been varnished and noting the elapsed time when the two varnished surfaces no longer stick. A second method is that proposed by the British Electrical and Allied Industrial Research Association. This method consists in placing a 1-lb. mass having a 1-in. diameter over a Whatman filter paper on top of varnished paper surface for one minute. The varnish is considered dry if it does not stick in this time. The results obtained to date are rather erratic and what is thought to be an improved method is under process of preparation for test.

Some work has also been done on the determination of the volatile constituents of varnish and a series of comparative tests are now under way.

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[1] See p. 1003—ED.

Molded Insulating Materials:

The activities of the sub-committee working on molded materials have been devoted mainly to studies dealing with tensile strength, dielectric strength, heat distortion, impact tests, and moisture absorption.

The question of the best shape of a tension test specimen has received a very considerable amount of attention. A specimen differing considerably from the figure eight now in use has been proposed for study. It has been shown that with this specimen, strengths of hot molded materials are from 50 to 100 per cent higher than have been obtained with the figure eight. The specimen proposed has its cross-section reduced by curved surfaces on both the edges and sides. It has been hoped that a specimen that would be flat on the sides could be developed, and thus simplify the mold construction. Up to the present, the efforts along this line have not been very fruitful. The work of Coker on photo-elastic studies of models has been reviewed and some little work done to determine the effects of clamping devices and shapes of curvature on the strains that are set up in a tension test specimen when subjected to tension. So far the work indicates that the most promising lead is to make the curvatures greater on both sides, but this necessitates increasing the length to undesirable proportions. It is likely that a compromise specimen will have to be chosen.

Tests for tensile strength have been made using the new form of specimen on shellac compounds, regular pitch cold molding compounds, and also on silicate cold-molded compounds. The advantage of the new specimen for these materials is evident but not so marked as in the case of hot-molded materials.

The sub-committee has recommended a change in the dielectric strength specimen from the cup to a disk as is stated in another part of this report.

Studies have been made which indicate the shortcomings of the present heat distortion apparatus. These refer particularly to the time required to make a single test and the use of soft solder in the construction of the apparatus, thus limiting the temperature range. Further work will be required before any changes can be recommended.

Studies have been made by two laboratories on the effect of the depth of the notch on the impact strength of the Izod specimen. The effect of velocity of impact has also been studied on both the canvas-base materials and the regular wood-flour filled molding compounds. Additional studies have also been made on the adaptability of the impact test to porcelain in conjunction with the sub-committee on porcelain. These various studies will probably be continued and recommendations made at a later date.

The question of water absorption of molding compounds has been raised on various occasions and work has been done by several laboa-s tories on this subject. These laboratories have used different shapto specimens and there does not seem to have been uniformity as rd procedure. It is thought that a more systematic and extensive seriee of studies should be made on this subject in order to throw light on the mechanism of water absorption. By joint action of Sub-Committee II on Molded Insulation and Sub-Committee III on Sheet Insulation an attempt will be made to work out methods of studying and determining water absorption that will be common to both lines of materials.

Sheet Insulating Materials:

The lines of study coming within the domain of Sub-Committee III have been numerous during the last year. These items are briefly discussed in the following paragraphs:

(*a*) *Insulating Paper.*—It has been shown that the folding endurance test and similar tests which are being considered in connection with it are most valuable in determining the deterioration of paper rather than in testing new paper. A method has been proposed of aging samples of paper after which they will be tested by the folding endurance test. This work will be combined with that on deterioration. The efforts on the latter subject have thus far been confined to collecting a review of the literature of the subject.

The work on porosity has been carried on largely by one laboratory and it has been shown that the densometer has a range better suited to paper with low air resistance, while the Pirelli tester is better for papers of high air resistance. The values obtained by both instruments are proportional for low air resistance but not for high air resistance.

In studying air resistance of papers it has been shown that closer limits for the viscosity of the oil were necessary in order to obtain the desired accuracy. The viscosity of the oil has been changed to 60–70 seconds, Saybolt, as is recommended in another part of this report.

Studies have been started on a new method of oil penetration. This work will be continued.

A new section of the committee has been organized to study the method of measuring the thickness of condenser tissue paper. The micrometers themselves will be checked against each other by means of metal gages, and then the method of using the micrometers will be studied.

(*b*) *Laminated Sheet.*—A rather extensive series of tests has been made by five laboratories by means of a bend machine designed by the Westinghouse Electric and Manufacturing Co. to study its possible suitability for making flexure tests on thin sheet laminated materials. This work will be continued.

(*c*) *Deterioration.*—As stated above, this work has been largely of a bibliographical nature. Further work will include the group which has been working on the folding endurance of paper.

(*d*) *Thermal Conductivity.*—Samples of graphite-rubber composition are being measured by a third laboratory which has constructed a flat plate heater apparatus for thermal conductivity measurements. After these have been checked, their values will be assumed as semi-standard and then by a straight temperature drop method compared with each other by three laboratories. If these prove to be dependable standards of thermal conductivity it will reduce the problem of the determination of thermal conductivities of sheet materials to a much simpler task, consisting of measuring the relative temperature drops, respectively, through them.

(*e*) *Dielectric Strength.*—For some time, the methods of testing sheet materials for dielectric breakdown (Methods D 149 - 24 T) have been under discussion. A series of tests has been made by nine laboratories comparing the A.S.T.M. dielectric test method with shorter-time tests proposed by Mr. Clark of the Pittsfield Works' Laboratory of the General Electric Co. The materials tested included quite a range of breakdown voltages. It was shown that the percentage variation from the mean for a given type of test by the different laboratories was practically the same for all laboratories for both methods of test. However, breakdown occurs higher up on the breakdown-voltage-time curve with Mr. Clark's method than with the A.S.T.M. method, thus making greater variations in breakdown voltage likely in commercial testing. It therefore seemed desirable not to make any change at present in the existing A.S.T.M. tentative methods.

(*f*) A section has been organized to investigate varnished cambric tape as to oil proofness, aging or heat resistance, dielectric strength under tension, and elongation. Methods have been outlined which will be tried by several laboratories.

Liquid Insulation:

Sub-Committee IV on Liquid Insulation has been active along several lines, some of which are briefly mentioned in the following:

(*a*) *Neutralization Value of Insulating Oils.*—Cooperative tests on the acidity of oil, using the revised General Electric Co. method have been made. Three laboratories check very well, but the fourth shows a considerable variation. A separate section of the sub-committee has been organized in order to carry out the development of this neutralization test more vigorously.

(*b*) *Life Test.*—Numerous suggestions on the life test have been collected and these have been assigned to different members of the committee for study. A new series of oil life test samples is being circulated to be tested according to the latest revision of the life test method.

(*c*) *International Electrotechnical Commission Activities.*—Samples of Pennsylvania and Mid-Continent crude oils are being sent abroad for cooperative life tests. Copies of the Swedish Sludge Test, and the German Sludge and Tar Test have been received and circulated. Copies of our life test have been sent to the central office in London for distribution to various national committees of the I.E.C. The sludge and tar tests will be reviewed by various members of Sub-Committee IV and their suggestions discussed at later meetings.

(*d*) *Testing of Electrical Insulating Oils.*—The Tentative Methods D 117 – 26 T are being recommended to be advanced to standard as noted earlier in the report.

Copies of a German report on Studies of Transformer Oils have been translated and circulated.

(*e*) *Dielectric Strength.*—A study of the results of dielectric strength of oils obtained by the A.S.T.M. gap and by the Allmänna Svenska Elektriska Aktiebolaget gap has been made. This shows the results obtained by means of the A.S.T.M. gap to have slightly smaller average deviations than those obtained with the A.S.E.A.

(*f*) *Federal Specifications Board.*—Items of Federal Specifications Board referring to transformer oil, and electric switch oil have been reviewed by the sub-committee and definite recommendations were made through the A.S.T.M. representative.

Porcelain Insulation:

(*a*) *Pore Volume.*—As referred to earlier in this report a test method for pore volume is being recommended to be adopted as tentative, and included as a part of Methods D 116 – 26 T.

(*b*) *Impact.*—Considerable work has been done on the subject of impact testing of porcelain, and Sub-Committee V on Porcelain Insulation has proposed a method of impact testing of porcelain. It was further recommended, however, that this method for porcelain be incorporated as a part of Methods D 256 – 26 T. Since certain revisions of the tentative standard are contemplated during the coming year, it was thought best to wait till later to make the revisions necessary to provide for porcelain.

(*c*) *Dielectric Breakdown.*—New methods of testing electrical porcelain for breakdown have been investigated and the committee has recommended a new method to replace the one appearing in Methods D 116 - 26 T.

Cable Splicing and Pothead Compounds:

The work of Sub-Committee VI on Cable Splicing and Pothead Compounds has been devoted to the following lines:

(*a*) *Dielectric Strength.*—Studies have been made on a modified form of the present A.S.T.M. test cup used for dielectric strength of splicing and pothead compounds. In addition to this, the Brooklyn Edison Laboratories have developed a new type of dielectric strength test cup which consists of a spherical electrode placed concentrically inside a hemispherical electrode so as to give a gap of 2 mm. The test made so far on the two types of test cup appear to be in favor of the new type proposed by the Brooklyn Edison Laboratories.

(*b*) *Consistometer.*—Considerable success has been achieved in the use of a modified consistometer using a metal orifice. So far it has been possible to use this at temperatures as low as —5° C. Some little difficulty has been experienced in securing uniform temperature throughout the mass.

(*c*) *Viscosity.*—Considerable work has been done in trying to use the MacMichael viscometer for pothead compounds cooled below their melting point. The indications are quite promising, special emphasis being given to modifications which would give exact control of the cooling curve.

Radio Frequency Tests:

Sub-Committee VII on Radio Frequency Tests has been particularly active in trying to work out a satisfactory method for power factor measurements of insulating materials at radio frequencies. What has for some time seemed to be an almost impossible task has been accomplished and the recommendations in another part of this report give the method recommended.

The following is the result of the letter ballot vote of the committee, which consists of 45 members, on the recommendations made in this report:

Items	Affirmative	Negative	Not Voting
PROPOSED REVISIONS OF STANDARD			
Standard Methods of Testing Molded Insulating Materials (D 48 - 24)	26	0	19
TENTATIVE REVISIONS OF STANDARD ADVANCED TO STANDARD			
Tentative Revisions of Standard Methods of Testing Molded Insulating Materials (D 48 - 24)	26	0	19
TENTATIVE METHODS TO BE ADVANCED TO STANDARD			
Tentative Methods of Testing Electrical Insulating Oils (D 117 - 26 T)	24	0	21
PROPOSED REVISIONS OF TENTATIVE STANDARDS			
Tentative Methods of Testing Untreated Insulating Paper (D 202 - 26 T)	26	0	19
Tentative Methods of Testing Sheet and Tape Insulating Materials for Dielectric Strength (D 149 - 26 T)	26	0	19
Tentative Methods of Testing Electrical Porcelain (D 116 - 26 T)	24	0	21
Tentative Methods of Testing Electrical Insulating Materials for Phase Difference (D 150 - 23 T)	23	0	22

This report has been submitted to letter ballot of the committee, which consists of 45 members, of whom 37 have voted affirmatively, none negatively, and 8 have refrained from voting.

Respectfully submitted on behalf of the committee,

H. S. VASSAR,
Chairman.

T. S. TAYLOR,
Secretary.

EDITORIAL NOTE

The Tentative Methods of Testing Electrical Insulating Oils were approved at the annual meeting as recommended by the committee, and subsequently adopted by letter ballot of the Society on September 1, 1927 to supersede the Standard Methods of Testing Transformer and Switch Oils. The methods appear in the 1927 Book of A.S.T.M. Standards, Part II. The revisions of the Standard Methods of Testing Molded Insulating Materials, accepted for publication as tentative in 1925 and 1926, were approved at the annual meeting as recommended by the committee, and subsequently adopted by letter ballot of the Society on September 1, 1927. The methods as revised appear in the 1927 Book of A.S.T.M. Standards, Part II.

The proposed revisions of the Standard Methods of Testing Molded Insulating Materials were accepted for publications as tentative and appear on page 1099.

The proposed revisions of the Tentative Methods of Testing Untreated Insulating Paper; of Testing Sheet and Tape Insulating Materials for Dielectric Strength; of Testing Electrical Porcelain; and of Testing Electrical Insulating Materials for Phase Difference were accepted. The methods as revised appear on pages 96, 67, 53 and 75, respectively.

APPENDIX

LIFE TEST FOR TRANSFORMER OILS

The life test for transformer oils is described in Appendix I to the 1923 report of Committee D-9[1] and also in appendices to the 1924[2] and 1925[3] reports. A revision of the previous descriptions is presented herewith. It includes improvements that have been made in the construction and operation of the apparatus, as the result of further experience in several laboratories.

APPARATUS

Referring to Figs. 1 and 2, *A* is a double-walled oven made of two sections of phenol laminated paper cylinders, the space between the cylinders being filled with asbestos. The bottom is made of two pieces of asbestos lumber separated with layers of asbestos paper. The dimensions of the oven are approximately 22 in. in outside diameter by 13 in. in depth. *L* is a removable cover of asbestos lumber encased in spun steel, the casing between lumber and steel being packed with layers of asbestos paper. It has a hole, *C*, 1½ in. in diameter, in the top for inserting the pipette to withdraw specimens of the samples. The lid also has a peep hole, *E*, through which can be seen an index plate to determine when the different beakers during the course of rotation in the oven are properly located under the hole *C*. These holes each have an aluminum pivot cover which should be kept closed when not in use. To the under side of the cover *L* is attached a steel condensation plate, slightly less in diameter than the inside of the oven and coned slightly so that condensed vapors, if any are formed, may drip safely beyond the edge of the beakers and thus eliminate the danger of contaminating the oil samples. There are two holes in this coned plate coinciding with holes *C* and *E* of the cover proper. *M* is a ¼-hp., 220-volt, 1800 r.p.m. constant-speed motor, directly connected to the horizontal worm shaft with a flexible coupling *F*. A hand wheel, *I*, is attached to the other end of the shaft to enable the operator when sampling to easily and quickly bring the beakers in line with the sampling hole *C*. This horizontal shaft is supported by ring oil bearings, *O*. The worm gear shaft, *G*, is vertical and is driven by a 240-tooth gear which meshes with the single thread worm gear *K* on the horizontal shaft. The vertical shaft is supported on a thrust bearing, *P*, at the bottom end. The upper end is supported with a composition brass and graphite bearing which does not require oiling. *T* is a thermostat, the bulb of which is located horizontally above the beakers in a plane just slightly above the top of the asbestos-covered steel center chimney shown in the working drawings. This chimney, supported centrally in the oven (see Fig. 3), induces a vertical current of warm air from the heating unit. Arriving at the top of the oven, the air current turns radially and downward, bathing the sample beakers on its way. The thermostat, when contact is made in it, energizes the coil of the relay, *X*. One of the sliding contacts (*Z*, Figs. 1, 2 and 4) is connected to the make and break of the relay. This is the high heat slide shown in Fig. 4. If the oven temperature falls, the thermostat contact is made, the relay operates, and the current flows from the 110 volt, alternating current line to the rheostat and then through the rheostat to contact *Z* and from there through the relay make and break and then through the heating unit. In this case, the least amount of external resistance is introduced into the circuit. If the oven temperature rises, the thermostat contact is broken and the relay contact is also broken. The current then must flow through the rheostat to contact *W* and from there to the heating unit flowing through the common pole on the relay but not through the make and break of the relay. In this case there is introduced a larger amount of external resistance and consequently less current flows through the heater. The amount of current flowing in the heating unit may be set at any suitable figure by means of the rheostat, *Y*, and the relay, *X*, as noted below under Adjustment of Apparatus.

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 23, Part I, p. 448 (1923).

[2] *Proceedings*, Am. Soc. Testing Mats., Vol. 24, Part I, p. 638 (1924).

[3] *Proceedings*, Am. Soc. Testing Mats., Vol. 25, Part I, p. 363 (1925).

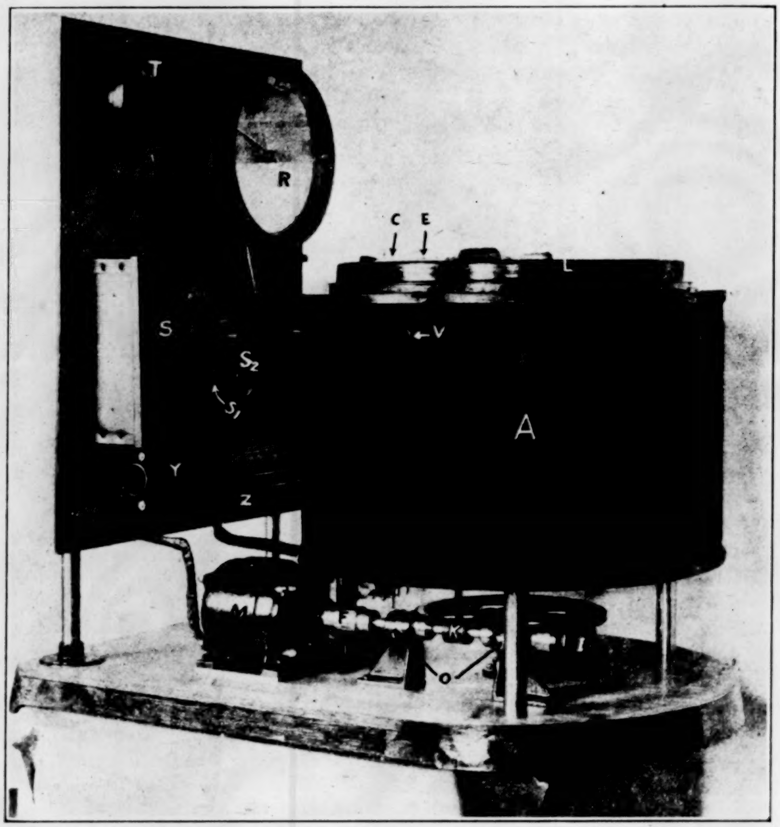

FIG. 1.—Apparatus for Conducting Life Test on Transformer Oils.

A wiring diagram showing how the relay, rheostat and heating unit are connected, is shown in Fig. 4. The heater of the oven is in one unit in the form of a 3-turn helix, freely exposed, under the central chimney and supported by suitable insulators on an iron spider lying on the floor of the oven. Its resistance when hot is about 20 ohms and the average current strength to maintain 120° C. is about 3.5 amperes, which means that the average power consumption is about 385 watts. *R* is a recording thermometer, whose bulb is located horizontally beside the thermostat bulb. *B* is a low form gas washing bottle, capacity 250 cc., which is filled three-quarters full with some good grade of transformer oil and serves as a tell-tale bottle to determine the rate of admission of air through the inlet tube *H*. Air is passed through this wash bottle and thence through pipe *D* into the oven at an approximate rate of 1.5 cu. ft. per hour, which is about equivalent to three or four bubbles per second when the internal diameter of the glass tube leading through the gas washing bottle is $\frac{3}{16}$ in. Excess air and gases escape from the oven at vent hole *V*. The revolving table inside of the oven is fitted with eight asbestos board seats, each of which holds a 600-cc. Griffin form Pyrex beaker approximately $3\frac{1}{2}$ in. in inside diameter and $4\frac{3}{4}$ in. high, containing 500 cc. of the oil sample to be tested.

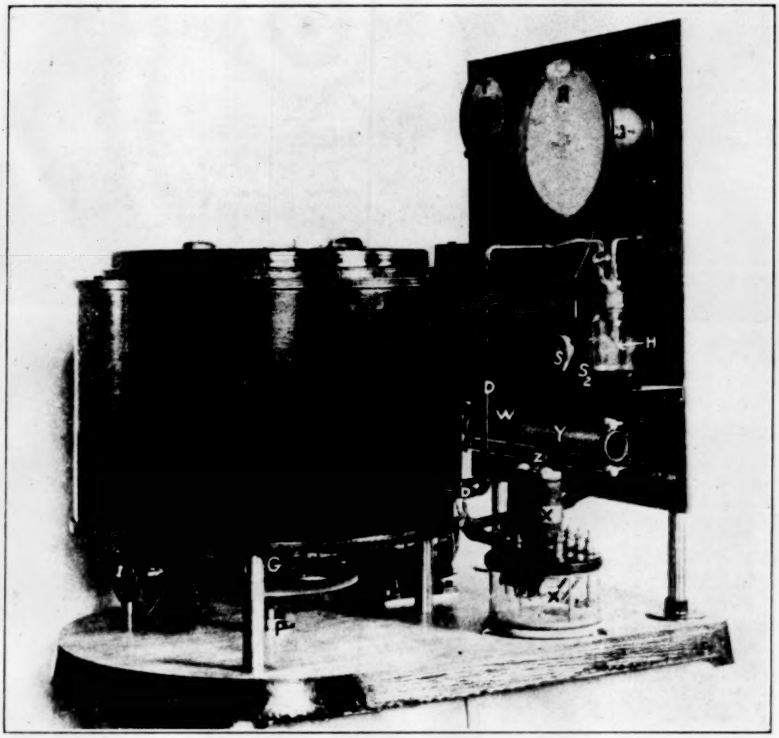

FIG. 2.—Apparatus for Conducting Life Test on Transformer Oils.

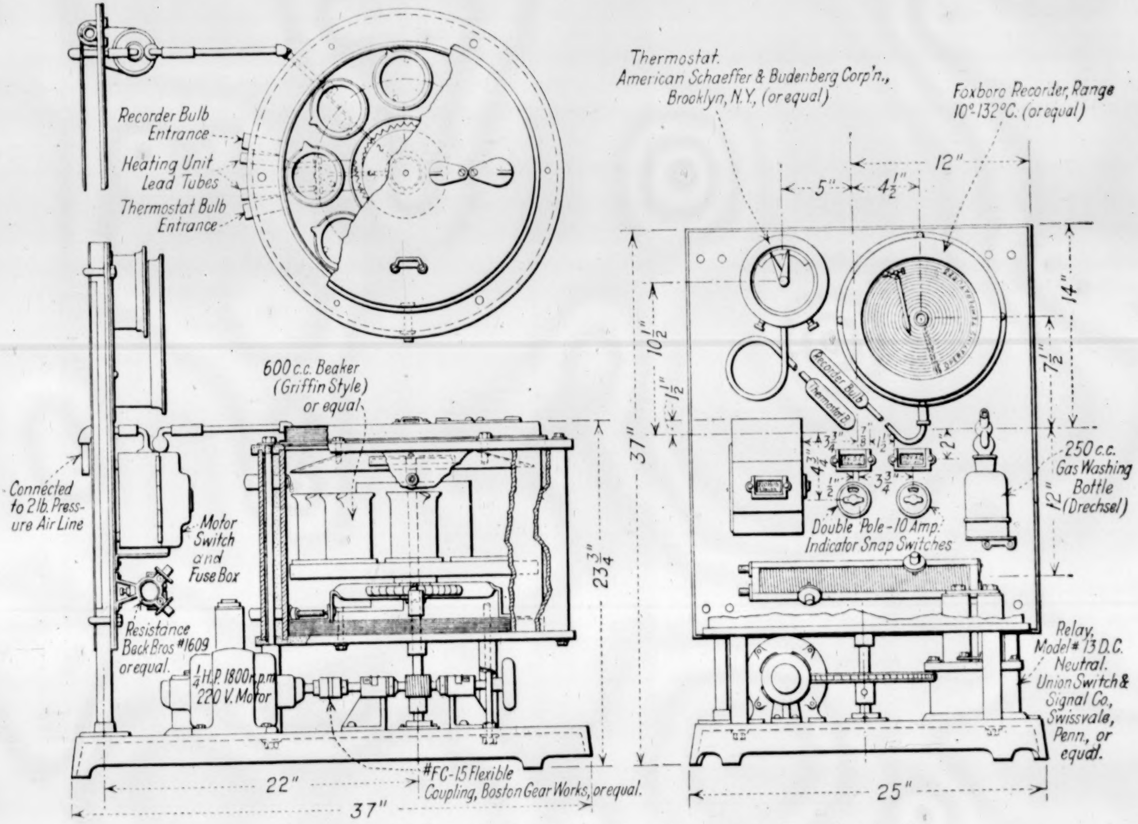
Recorder Bulb Entrance
Heating Unit Lead Tubes
Thermostat Bulb Entrance
600 c.c. Beaker (Griffin Style) or equal
Connected to 2 lb. Pressure Air Line
Motor Switch and Fuse Box
Resistance Back Bros #1609 or equal.
1/4 H.P. 1800 r.p.m. 220 V. Motor
23 3/4"
22"
37"
#FC-15 Flexible Coupling, Boston Gear Works, or equal.
Thermostat. American Schaeffer & Budenberg Corp'n., Brooklyn, N.Y., (or equal)
Foxboro Recorder, Range 10°-132°C. (or equal)
5"
4 1/2"
12"
14"
7 1/2"
10 1/2"
1 1/2"
37"
Recorder Bulb
Thermostat B.
4 3/4"
7/8"
1 1/2"
2"
4 3/4"
1"
1/2"
3 3/4"
Double Pole - 10 Amp. Indicator Snap Switches
250 c.c. Gas Washing Bottle (Drechsel)
12"
Relay, Model # 13 D.C. Neutral. Union Switch & Signal Co., Swissvale, Penn., or equal.
25"

FIG. 3.—Details of Apparatus for Conducting Life Test on Transformer Oils.

ADJUSTMENT OF APPARATUS

When starting a new machine for the first time, proceed as follows:

1. Fill the eight spaces in the apparatus with samples of oil (500 cc. of oil in a 600-cc. beaker) and adjust the air flow through wash bottle *B* to about 1.5 cu. ft. per hour. (See Note 4.)

2. Start the motor which rotates the samples by closing switch *S*.

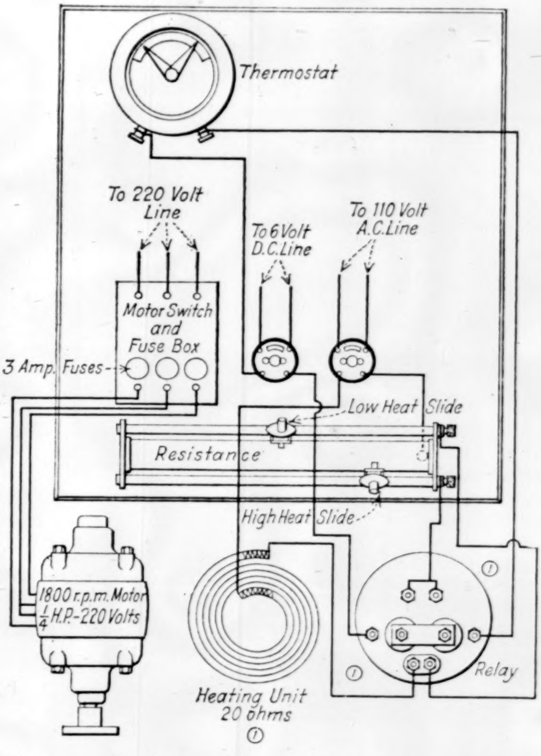
Thermostat
To 220 Volt Line
To 6 Volt D.C. Line
To 110 Volt A.C. Line
Motor Switch and Fuse Box
3 Amp. Fuses
Low Heat Slide
Resistance
High Heat Slide
1800 r.p.m. Motor $\frac{1}{4}$ H.P.-220 Volts
①
Relay
Heating Unit 20 ohms

FIG. 4.—Wiring Diagram for Apparatus for Conducting Life Test on Transformer Oils.

3. Move the thermostat pointer beyond the 140° C. mark, that is, off the scale, by turning in a clock-wise direction the thumb screw on the face of thermostat *T*. (Note.—Old style machines have thumb screw on the side of thermostat.)

4. Turn on snap switch S_2 of heater circuit (110 volt, alternating current) and move slide contacts *W* and *Z* of the rheostat *Y* to the center of rheostat. Switch S_1 must be open during this operation and kept open until time as noted under item 7.

5. Move slide contact *W* until a glass stem thermometer inserted into one of the beakers of oil through hole *C* reads about 110° C. Enough time

should be allowed to let the oven come up to full temperature. A good plan is to allow the oven to operate over night on this low heat. Thermostat pointer must remain off the dial until as noted under item 7.

6. Snap on relay switch S_1 and move the sliding contact Z controlling the relay X to the right, away from sliding contact W until the oil temperature reads 130° C.

7. Leaving the two sliding contacts as they are, set the thermostat pointer on the 120° C. mark.

8. After the oven has been operating at least several hours and preferably over night as in item 7, stop the rotating motor and measure accurately the temperature of the oil samples by inserting a thermometer through sampling hole C in the cover and into the oil. Measure at least five samples or beakers, always stirring the oil before taking a reading. Start the motor again and move the pointer on the thermostat up or down as may be necessary to bring the oil samples precisely to 120° C. The dial reading on the thermostat may be different from the actual oil temperature. In this case, disregard the thermostat dial reading.

9. When the oil temperatures stay constant at 120° C., set the recording thermometer so that it also registers 120° C.

NOTES

1. It is imperative to insulate the thermostat and recorder tubings which enter at the side of the oven. A good plan is to fix them permanently in the inlet holes with a split cork and then wind the tubes with felt for a distance of at least 6 in., measuring from the cork on the outside of the oven. There must be no heat leakage from the oven through the tubing.

2. If the recorder gives a line showing rather large irregular dips, with comparatively long intervals, it is an indication that either a thermostat bearing is sticking due to friction or the contacts do not separate freely because they are dirty. If the line shows large and regular dips, it is a sign that there is too much play in the bearings. The thermostat bearings and contacts must operate perfectly to give good results. There must be no friction and neither may there be any looseness or play. When the machine is operating properly, it will give a continuous line of closely set jags lying on the 120° C. mean, within a range of ±0.5° C.

3. The thermostat bulb and the recorder bulb must be placed in a horizontal position above the beakers in a plane just level with the top edge of the asbestos-covered central steel chimney. The air temperature here is at a maximum. They must not be placed directly over the chimney, where they would be heated mainly by radiation, but should be placed where they get the effect of the convection currents. The tubings, after passing through the oven inlet hole, should be bent so that the bulbs lie just over the outer edge of the beakers, the thermometer bulb being nearest the outside wall of the oven and the thermostat bulb being along the side of the thermometer bulb and nearest the heater. Bind both bulbs together with bare copper wire so that they are rigidly and permanently fixed in one position and conduct heat to each other freely.

4. It is not necessary to have exactly 1.5 cu. ft. of air passing into the oven per hour. Actual tests have shown that the air may vary from about 1.0 to 2.0 cu. ft. per hour without changing the results of the test. Tests in one laboratory have indicated that it is not necessary to wash the air before passing it into the oven. It is possible, however, that in this case the unwashed air was pure. It is recognized

that impurities such as SO_2, free chlorine, etc., if present in the air, would accelerate oxidation, and if such impurities are known to be present, it is necessary to first wash the air with suitable chemicals. For example, it might be passed through a solution of KOH and then through concentrated sulfuric acid.

PROCEDURE OF TEST

After the machine has once been adjusted, it should be capable of continuous operation with practically no further adjustments. The procedure of the test is as follows:

1. It is imperative to have the beakers absolutely clean. A very slight film of varnish from a previous test, even though the film is barely discernible when the beaker is held to the light, is enough to cause an error in the test due to the accelerating catalytic action of the slight amount of oxidized oil film. Therefore, clean the beakers as follows:

Wash first with benzol, then with acetone to remove sludge and varnish. If this does not remove it, soak the beaker in caustic solution. Then, after rinsing with water, scrub with scouring soap or detergent and water, rinse thoroughly with water and rinse with cleaning solution of potassium bichromate and sulfuric acid. Rinse again thoroughly with water, finishing with distilled water and dry the beakers upside down in a hot closet free from dust. Do not dry the beakers with towels.

2. Filter into the clean beakers through a good quality, dry filter paper, 500 cc. of the oil sample. Be careful not to contaminate the oil by measuring it with an unclean graduate, or filtering through an unclean funnel. It is a good plan to have an etched mark on the side of the beaker indicating the 500-cc. capacity mark and then filter directly into the beaker from the sample can.

3. When the oven has been adjusted to the operating temperature, as noted under Adjustment of Apparatus above, the lid is removed, the eight filled beakers used for adjusting the temperature are taken out and eight beakers containing oil to be tested are quickly put in place and the lid then replaced. The oven temperature will, of course, drop, but it should come up to temperature in about 1½ hours. The time at which the oil samples are placed in the oven is noted and considered as the beginning of the run, although the recorder will not show the test temperature for one to two hours, due to the cooling which takes place while putting the samples in the oven. As the oxidation at this low temperature (120° C.) is quite slow, several days at least will usually have elapsed before any sedimentation occurs, even with the poorest grades of oil. Once a day the motor is stopped and the samples are examined by momentarily lifting from the bottom of the beaker a specimen of the oil in a dry clean, 10-cc. pipette, which is inserted in the sampling hole C. Before drawing up the specimen, the oil should be thoroughly stirred with the pipette. (See Note 8 below.) As soon as any sample is found to be near the sludging condition, 10 cc. of the oil are removed and placed in a 15-cc. centrifuge tube having a tapering end. The tube is corked with a clean cork to keep dust from settling in the tube. From this time on specimens are withdrawn daily from the oils which are suspected of sludging. The specimens, properly labeled with the date and number of the sample, are allowed to stand in the dark for not less than 15 or more than 24 hours and are then centrifuged at 1800 r.p.m. for twenty minutes. The tubes are then withdrawn and examined by holding

the tube over a white surface and observing sediment by transmitted light. The number of days which elapse before the first trace of sludge appears in this specimen (see Note 12 below) is recorded as the time required to produce sludging in the sample from which it was removed. The time interval counted is the time from when the sample is placed in the oven until the time when the first trace of sludge is noted in a specimen removed from the sample. The time the specimen stands outside of the oven before centrifuging is not counted.

NOTES

5. An operator, after some experience with this method, will be able to judge fairly accurately from the darkening of the oil samples when they are approaching the sludging period. When starting with an unknown oil it may be necessary to remove specimens quite early and frequently and then repeat the run without removing specimens, allowing it to proceed close to the time when sludging first would start. The point to be borne in mind, of course, is that the test will check more accurately with the minimum number of specimens removed before sludging begins. In case the first specimen withdrawn shows sediment, the tests must be repeated and earlier specimens taken.

6. Sometimes oil specimens after being removed from the oven and allowed to stand in the centrifuge tubes may deposit sludge two or three days after standing. It is important therefore that all specimens be observed *within* the fifteen to twenty-four hour period after removal from the oven. Any results obtained after this twenty-four hour period should be disregarded. A good plan is to withdraw specimens just before the close of a day and examine them in the forenoon of the next day. Specimens should not be allowed to stand in direct sunlight, nor should they stand near steam pipes or radiators or in similar locations where they will be kept warmer than the prevailing room temperatures ranging from about 20 to 30° C.

7. It is also imperative, of course, that the samples are not contaminated during the run. Avoid inserting into the oil, pipettes that are not absolutely clean and dry when taking specimens. A clean dry pipette should be used for each specimen.

8. Stir the oil with the pipette before taking the specimen, but do not stir it by blowing through the pipette. It can be sufficiently stirred mechanically with a long stem pipette, inserted through the sampling hole. Introduction of moisture or other gases by blowing may disturb the test. For the same reason when drawing oil up in a pipette for examination always allow it to flow back by gravity.

9. It is good practice to check the recorder by taking daily checks of the oil temperatures with a thermometer inserted through the sampling hole and noting the temperature after stirring the oil. The oil should be kept at 120° C. The importance of keeping the oil at a uniform temperature of 120° C. can be judged from the fact that it has been proved that for one type of transformer oil, an increase of 8 to 9° C. doubles the rate of oxidation. If too many specimens have been removed from a sample the temperature of the remaining oil may rise above 120° C. while the temperature in the fuller beakers may register 120° C. If this occurs, it is well to check the sample in a new run and start removing specimens at a later date. A safe rule to follow is to repeat the test when more than a total of 150 cc. of specimens have been removed from the 500-cc. sample before the sludging point has been reached.

10. The total resistance of the rheostat should be so chosen that on the hottest day the minimum heating current (relay contacts open) will not raise the oven

temperature quite to 120° C. Conversely the sliding contacts should be adjusted to such a distance apart that when the oven is in operation the recorder chart shows not a smooth wavy line, but a line full of very closely set jags lying on the 120° C. mean.

11. It is, of course, not necessary to wait until all the samples in the oven have reached the sludging point before starting a new series of samples. As soon as one sample has sludged, it can be quickly removed and another sample quickly inserted. The slight drop of temperature in the oven, due to removing the cover for a short time, will be regained in less than an hour and the error introduced by this short-time drop, when compared to the total life of the oil, is negligible.

12. *Haze Point and Sludge Point.*—It will be noticed, on examining a centrifuged specimen in front of a concentrated light, that it remains clear for the greater part of its life. About two or three days before it may be expected to sludge, a haze may develop, which can very plainly be seen with the concentrated light behind. This haze, of course, is incipient sludge (sludge in colloidal form). The oil at this point may be said to be saturated with the oxidized bodies produced during the run, which up to this point have gone into true solution and, incidentally, greatly darkened the oil. After the saturation point is reached, the colloidal particles become more and more coarse as they become more and more numerous, until the sludging point is reached. This is defined as the point at which the first trace of deposit is seen at the bottom of the centrifuge tube in a specimen which has been centrifuged after standing for not less than 15 or more than 24 hours after its removal from the oven.

If it is questionable whether the first appearance of sediment which is noted is sludge or merely some other foreign matter in the centrifuging tube, it is well to continue the test for several days. If it was sludge, the next day's specimen usually shows a greater amount of sediment in the tube.

REPORT OF COMMITTEE D-11

ON

RUBBER PRODUCTS

Two meetings of Committee D-11 have been held during the past year in addition to the meeting held at the annual meeting, namely, at Akron, Ohio, on October 13, 1926, and at Philadelphia on March 17, 1927. The committee proposes revisions, as indicated below, of the following three standard specifications, with the recommendation that these revisions be accepted for publication as tentative.

- Standard Specifications for Rubber Belting for Power Transmission (D 53 - 24);
- Standard Specifications for Rubber Pump Valves (D 151 - 23);
- Standard Specifications for Adhesive Tape for General Use for Electrical Purposes (D 69 - 24).

The committee further recommends revisions in the Tentative Specifications for Rubber Insulating Tape (D 119 - 22 T) and that the tentative specifications, as revised, be continued as tentative.

The revisions proposed in the specifications are as follows:

Standard Specifications for Rubber Belting for Power Transmission (D 53 - 24).[1]—

Section 11.—Change the last sentence to read as follows by the addition of the italicized figures and the omission of those in brackets:

> "The rate of separation of the jaws shall be approximately [1½ to 4 in.] *½ to 2 in.* per minute."

Section 14.—In place of the ravel test at present specified, include a reference to the grab test as described in the Standard Methods of Testing Cotton Fabrics (Serial Designation: D 39) of the American Society for Testing Materials.[2]

Standard Specifications for Rubber Pump Valves (D 151 - 23).[1]—

Section 4 (c).—Eliminate reference to reclaimed rubber.

Standard Specifications for Adhesive Tape for General Use for Electrical Purposes (D 69 - 24).[1]—

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[1] 1924 Book of A.S.T.M. Standards.

[2] 1927 Book of A.S.T.M. Standards, Part II.

Title.—Change the word "adhesive" to "friction."

Section 1.—Change the first sentence to read as follows by the addition of the italicized word and the omission of those in brackets:

> "These specifications cover commercial [adhesive] *friction* tape [(also called 'friction' tape)] consisting of strips of cotton sheeting impregnated with an adhesive insulating compound."

Section 7.—In the first sentence, change the words "strong light" to "window light."

Section 9.—Change Paragraph (*a*) from its present form: namely,

> "The adhesion between adjacent layers of the tape shall be such that when a strip of tape 2 ft. long is taken from a roll and wound upon a mandrel 1 in. in diameter under a tension of 10 lb. per inch of width at a rate of 30 in. per minute, and allowed to stand for three minutes with the weight attached, a weight of 4 lb. per inch of width shall not cause the plies to separate at a rate greater than 30 in. per minute.
>
> "The test shall be made at a room temperature not less than 21.1° C. (70° F.) nor more than 23.9° C. (75° F.), the sample having been kept within these limits for at least 30 minutes immediately preceding the time of testing.
>
> "The mandrel shall be so free in its bearings that a weight of 1 oz. will cause it to revolve freely when suspended from a cotton string wound in a single layer on the center of the mandrel."

to read as follows:

> "The adhesion between adjacent layers of the tape shall be determined as follows: A sample 23 in. long shall be removed from the roll, care being taken not to touch the surface to be tested with the hands or otherwise. Two inches of the sample shall be wound on the mandrel described below and a weight of 10 lb. per in. of width of the tape shall be attached to the end of the sample and 19 in. of the sample wound onto the mandrel at a uniform rate of 12 in. per minute. The tape shall be allowed to stand for three minutes with the weight attached after which a weight of 4 lb. per inch of width shall be substituted for the weight of 10 lb. per inch of width, and the tape allowed to unwind. After 2 in. have unwound, the rate of unwinding shall not be greater than 15 in. in one minute.
>
> "The temperature of the room and the temperature of the tape shall be not less than 20° C. (68° F.) nor more than 22.2° C. (72° F.).
>
> "The mandrel used shall be ¼ in. in diameter and shall be mounted in a level position in Fafnir Bearing Co. ball bearings, Catalog No. 0.096 or equivalent ball bearings. The mandrel shall turn freely under the weight of 5 g., suspended from a cotton thread wound in a single layer on the center of the mandrel."

Section 12.—In the first column of the table appearing in this section, add the word "nominal" before the word "thickness."

Tentative Specifications for Rubber Insulating Tape (*D 119 - 22 T*).[1]—The following changes are recommended:

Section 2.—Change to read as follows by the addition of the italicized words:

"The tape shall be ***made from an unvulcanized*** rubber compound which shall be well, evenly and smoothly calendered, cut to uniform width and tightly wound in rolls with a glazed cloth, parchment paper or a linen separator interposed between adjacent layers."

Section 5 (*a*).—Change the reference to "Fig. 1" to "Fig. 2," in order to correct a typographical error.

Section 6 (*a*).—Change to read as follows by the addition of the italicized figures, and the omission of the figures in brackets:

"The tensile strength of the tape shall be not less than [300] *250* lb. per sq. in.

Section 6 (*b*).—In the first sentence, insert the word "preferably" between the words "shall" and "be."

Section 8.—Change from its present form: namely,

"The tape when wrapped to a thickness of ¼ in. and heated to a temperature of 150° F. (65.5° C.) for 20 minutes shall fuse into a homogeneous mass."

to read as follows:

"The tape shall be tested for fusion as follows:

"(*a*) The sample shall have been kept at a room temperature of not less than 65° F. (18° C.) nor more than 90° F. (32° C.) for at least 30 minutes previous to making the test.

"(*b*) The sample shall be tested on a mandrel ¼ in. in diameter which shall be mounted in a level position in ball bearings of the Fafnir Bearing Co., Catalog No. 0.096 or equivalent ball bearings. The mandrel shall turn freely under a weight of 5 g. suspended from a cotton thread wound in a single layer on the center of the mandrel.

"(*c*) A sample 7 in. long shall be taken from the roll, care being taken not to touch the surface to be tested with the hands or otherwise, and 2 in. of the sample shall be wound on the mandrel, and then a weight of 4 lb. per inch of the width of the tape shall be attached and the tape wound on the mandrel for 3 in. at the uniform rate of approximately 15 r.p.m. The tape shall stand for 3 minutes with the weight attached and then allowed to unwind at the same rate until the fused turns are reached. The tape shall then sustain the weight for 2 minutes without further unwinding or shall break at the point of unwinding."

No new specifications are being presented this year.

One new sub-committee has been organized during the year, namely, a Sub-Committee on Rubber Products Designed to Absorb Vibratory Shocks, under the chairmanship of L. C. Conradi.

As indicated in the report of the committee for 1926, the activities of the Sub-Committee on Performance Tests for Rubber Products have been resolved for the present under three progressive and resourceful sub-groups. In fact, the research programs under each are creating such an interest and data are being presented so rapidly that the three sub-sub-committees have been made sub-committees of Committee D-11 designated as follows: Sub-Committee on Abrasive Tests (F. G. Breyer, chairman), Sub-Committee on Flexing Tests (W. L. Sturtevant, chairman) and Sub-Committee on Life and Aging Tests (J. P. Coe, chairman).

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 22, Part I, p. 934 (1922); also 1926 Book of A.S.T.M. Tentative Standards, p. 912.

The following resolution was adopted to guide the committee in its future activities:

> Resolved that the efforts of Committee D-11 be devoted mainly to the study of modern methods of test in their application to various rubber products, with a view of formulating "standard methods" of test and the promotion of their use in the industry.

Where the words "standard methods" are used above, chemical, physical and performance tests are implied.

In addition to last year's plan on abrasion tests the committee has found its research program has proved of definite interest to the extent that a series of experiments will be conducted using several present day active rubber compounds. It is the sub-committee's plan to include all abrasion machines of any note in its testing program.

The flexing machine described in the report last year, while not being recommended at this time by the committee to be incorporated as a means of test in any commercial specifications, has established itself as a definite guide in determining the life of rubber belts. Five machines were announced in service last year. The number has since been increased to eleven. During the coming year the committee will continue its program of comparing dynamometer tests on rubber belts with those already obtained with the flexing machine.

The Sub-Committee on Aging or Life Tests has to date been unable to report any data accumulated since its organization; but all manufacturers and many consumers are vitally interested and have much individual data on hand. While it is most difficult for this sub-committee to arrange a workable research program, its problem is undoubtedly the most important and has created intense interest as evidenced by the many applications from both producers and consumers for membership on this sub-committee.

The Sub-Committee on Valves for Fire Alarm Systems has been discharged due to lack of interest on the part of consumers.

The recommendations appearing in this report have been submitted to letter ballot of the committee with the following result:

Items	Affirmative	Negative	Not Voting
I. TENTATIVE REVISIONS OF STANDARD SPECIFICATIONS			
1. Standard Specifications for Rubber Belting for Power Transmission (D 53 - 24)	17	1	9
2. Standard Specifications for Rubber Pump Valves (D 151 - 23)	18	2	7
3. Standard Specifications for Adhesive Tape for General Use for Electrical Purposes (D 69 - 24)	21	1	5
II. REVISION OF TENTATIVE STANDARD			
4. Tentative Specifications for Rubber Insulating Tape (D 119 - 22 T)	15	1	8

This report has been submitted to letter ballot of the committee, which consists of 49 members, of whom 28 have voted affirmatively, one negatively, and 20 have refrained from voting.

Respectfully submitted on behalf of the committee,

F. G. BREYER,
Chairman.

E. H. GRAFTON,
Secretary.

EDITORIAL NOTE

The proposed revisions of the Standard Specifications for Rubber Belting for Power Transmission; for Rubber Pump Valves; and for Adhesive Tape for General Use for Electrical Purposes were accepted for publication as tentative and appear on pages 1096 to 1098.

The proposed revisions of the Tentative Specifications for Rubber Insulating Tape were accepted. The specifications as revised appear on page 1028.

REPORT OF COMMITTEE D-13

ON

TEXTILE MATERIALS

Committee D-13 on Textile Materials held two meetings during the year. The fall meeting was held at Cleveland, Ohio, on October 21 and 22, 1926. The spring meeting was held at the Massachusetts Institute of Technology in Cambridge, Mass., on March 11 and 12, 1927. Both meetings were well attended and were very satisfactory in every way.

One new sub-committee has been authorized during the year:

Sub-Committee XXI on Raw Cotton.

This sub-committee is an outgrowth of the committee's intent to write specific specifications for certain cotton fabrics and yarns in which the characteristics of the raw cotton may form a part of the specifications. The sub-committee is not yet organized but has reached a stage such that the organization will be complete and work begun in the very near future.

Committee D-13 submits three new tentative standards as appended hereto:[1]

1. Tentative Specifications for Tolerances and Test Methods for Certain Light and Medium Cotton Fabrics;
2. Tentative Specifications and Tests for Cuban (Jute) Raw Sugar Bags;
3. Tentative Methods for Identification of Textile Fibers and Their Quantitative Determination in Mixed Goods.

The first two of these new tentative standards are the result of work of two new sub-committees authorized last year and organized this year, Sub-Committee XVII on Light and Medium Cotton Fabrics and Sub-Committee XVIII on Sugar Bags, respectively.

The third one of these new tentative standards has grown out of the change of name and purpose of Sub-Committee IV the name having been changed to Identification of Textile Fibers.

Two sub-committees authorized by the committee last year are still in process of organization; the Sub-Committee on Worsted and Woolen Yarns and the Sub-Committee on Worsted and Woolen Fabrics. These two sub-committees were authorized with a view to expediting the work on wool and worsted products and of confining the work of Sub-Committee XII to Raw Wool. The work of Sub-Committee XII is progressing slowly but surely and will lead to organization and active work in Sub-Committees XIX and XX in due course along with the work of Sub-Committee XII on Raw Wool.

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[1] See pp. 1039, 1041 and 1044.—Ed.

Committee D-13 submits, appended hereto,[1] revisions of the following four existing standards:

1. Standard Methods of Testing Cotton Fabrics (D 39 - 24);[2]
2. Standard Specifications for Imperfections and Tolerances for Square Woven Tire Fabrics (D 122 - 25);[3]
3. Standard Specifications for Imperfections and Tolerances for Cord Tire Fabrics (D 179 - 25);[3]
4. Standard Specifications and Tests for Osnaburg Cement Sacks (D 205 - 25).[3]

The first of these revisions is a somewhat modified form of the proposed General Methods of Testing Textile Fabrics published as information with the 1926 report of the committee.[4]

The second and third revisions are not very different in form and substance from the present specifications except that in both the definitions of defects and the scoring system of evaluation have been eliminated. The definitions have been completely incorporated in the Tentative Definitions of Terms Relating to Textile Materials (D 123 - 26 T) and are not necessary to the two specifications in view of the scoring system of evaluation having been omitted.

The fourth revision is an adjustment of some tolerances and changes in the form but not the substance of some paragraphs and a revision as to retests and use in purchase specifications.

All four are for practical purposes standards since the revisions have been made with care as a result of experience with the standards before revision. The procedure governing the adoption of standards requires that they be published as tentative with the possibility of being continued as tentative until 1930 when the Book of Standards is next published unless adopted as standard by a nine-tenth's vote at the annual meeting. The committee recommends that they be adopted as standard immediately to appear in the 1927 Book of Standards.

Committee D-13 recommends the advancement to standard of the following six tentative standards:

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[1] See 1927 Book of A.S.T.M. Standards, Part II, pp. 900, 884, 888 and 898.—ED.

[2] 1924 Book of A.S.T.M. Standards.

[3] A.S.T.M. Standards Adopted in 1925.

[4] *Proceedings*, Am. Soc. Testing Mats., Vol. 26, Part I, p. 482 (1926).

1. Specifications for Textile Testing Machines (D 76 - 25 T);[1]
2. Specifications for Tolerances and Test Methods for Cotton Yarns, Single and Plied (D 180 - 25 T);[1]
3. Specifications for Tolerances and Test Methods for Cotton Sewing Threads (D 204 - 25 T);[1]
4. Specifications for Tolerances for Numbered Cotton Ducks (D 230 - 25 T);[1]
5. Specifications for Tolerances and Test Methods for Electrical Silk and Cotton Tapes (D 259 - 26 T);[2]
6. Definitions of Terms Relating to Textile Materials (D 123 - 26 T),[2] revised as indicated below.

It is recommended that the first of these tentative standards be amended by inserting a sub-title, "*A*.—Tensile Testing Machines," before the text, in order that other types of testing machines (such as gage machine for measuring thickness, etc.) when standardized may be added under *B*, etc., so that all standardized types of machines for testing textiles may be described in the one standard.

The remaining tentative standards mentioned, with the exception of Definitions D 123 have had only editorial revisions since publication as tentative. The first four were ready for advancement last year but were continued as tentative in 1926 at the suggestion of the Executive Committee of the Society to avoid unnecessary printing costs.

The editorial revisions in Specifications D 180 - 25 T and D 204 - 25 T, made necessary by the incorporation of all definitions of terms in Definitions D 123, are as follows:

In both specifications change Section 4 to read as follows:

> "*Direction of Twist.*—The direction of twist shall be as defined in the Standard Definitions of Terms Relating to Textile Materials (Serial Designation: D 123) of the American Society for Testing Materials."

The following detail actions relative to the Tentative Definitions of Terms Relating to Textile Materials (D 123 - 26 T) are recommended:

Advance to standard without change, the present definitions for:

Thick and Thin Places (Major Defects); Thick and Thin Places (Minor Defects); Missing Warp (Yarn or Cord); Pucker (Puff or Blister); Slack and Tight Warp or Filling Yarns or Cords; Slug; Sewed Yarn; Corkscrew Twist; Mispick or

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 25, Part I, pp. 829–841 (1925); also 1926 Book of A.S.T.M. Tentative Standards, pp. 915, 917, 929, 932.

[2] *Proceedings*, Am. Soc. Testing Mats., Vol. 26, Part I, pp. 1077–1085 (1926); also 1926 Book of A.S.T.M. Tentative Standards, pp. 938, 948.

Broken Pick; Float; Kink; Split or Chafed Yarn or Cord; Dirty Yarn; Wrong Ply Warp (Yarn or Cord); Wrong Draw; Oil Spot; Mixed Yarn of Inferior Grade; Irregular Pick; Smash; Baggy Fabric; Wrong Ply Filling Yarn; Mixed Yarn or Cord; Defective Splice.

Tire Builder Fabric; Tire Cord Fabric; Hose Duck; Rubber Belt Duck; Balata Belt Duck; Oil Belt Duck, Numbered Duck; Army Duck; Single Filled or Flat Duck; Enameling Duck.

Twill; Drills; Alberts; Jeans; Serge; Clay.

Count; Crimp.

It is further recommended that the Conversion Table of Linear Yard Weight to Square Yard Weight of Fabric be advanced to standard without change.

It is recommended that the definitions of the following terms be revised and advanced to standard in their proposed revised form as given below:

Standard Atmosphere.—In the case of textiles, an air condition in which the relative humidity is 65 per cent at a temperature of 21° C. (70° F.).

Standard Condition.—In the case of textiles, the moisture condition of a material when it is in moisture equilibrium with a standard atmosphere.

Standard Regain.—In the case of any specific textile material, an agreed or officially adopted percentage allowance of moisture added to the absolute dry weight of a material to determine its standard weight.

Standard Weight.—In the case of textiles, the absolute dry weight of a material plus its standard regain.

Moisture Content (Moisture, Percentage of Moisture).—In the case of textiles, moisture present in a material shown as a percentage of the net weight.

Yarn.—An assemblage of fibers or filaments of animal, mineral, or vegetable origin, either natural or manufactured, twisted or laid together to form a strand or group of strands for use in weaving, knitting, or forming in any manner into textile fabrics.

Cord.—A string or small rope of fibrous material made by twisting together, generally with hard twist, several yarns for use in tying, binding, lacing, etc., and in weaving or laying very heavy fabrics.

Thread.—A fine cord composed of two or more yarns twisted together, for use in sewing.

Lea.—The division of a hank (840 yd.) of cotton yarn, 120 yd. made up of 80 turns on a standard cotton reel. Also a hank of linen yarn, 300 yd., used as the basis of the linen yarn count.

Ends.—The individual warp yarns running lengthwise of a fabric.

Picks.—The individual filling yarns running across a fabric.

Plain Weave.—A fabric pattern in which each yarn of the filling passes alternately over and under a yarn of warp.

Twist, Direction of.—In the case of yarn or cord, the yarn or cord has right-hand or regular twist if when it is held vertically, the spirals or twists are seen to incline upward in a right-hand direction and has left-hand or reverse twist when the spirals or twists are seen to incline upward in a left-hand direction.

NOTE.—Attention is called to the fact that this definition of twist is opposite to that used in sewing thread manufacture.

Off-Square.—In the case of fabric, the percentage of warp crimp minus the percentage of filling crimp.

Bad Start-up.—Requires no definition.

Knot.—A joining by tying of portions of a full-ply yarn in the fabric.

Reed Mark.—Marks or lines up the warp way of the cloth, usually caused by too many warp yarns being drawn into a dent, a faulty setting of the loom or imperfections in the reed.

Imperfect Selvage.—Tight, slack, broken, weak, nicked, or open selvage.

It is further recommended that the definitions for the terms "regain (moisture regain)" and "gage" be continued as tentative in their present form.

The following new definition for the term "loop knot" is recommended for publication as tentative:

"*Loop Knot.*—Snarl or curl produced by a weft yarn receding upon itself."

Committee D-13 will continue the following four tentative standards with expectation of revision within the year:

1. Tentative Specifications for Tolerances and Test Methods for Rayon (D 258 - 26 T);[1]
2. Tentative Specifications for Tolerances and Test Methods for Knit Goods (D 231 - 25 T);[2]
3. Tentative Methods of Testing Cotton Fibers (D 152 - 22 T);[3]
4. Tentative Methods of Testing Grease Wool and Allied Fibers for Scoured Content (D 232 - 25 T).[4]

The first of these, Specification D 258, is receiving slight revision this year but is not yet ready to pass to standard on account of lack of sufficient data to place some of the constants and tolerances beyond question. The revision recommended this year is a change in Section 9, making this section read as follows by the addition of the italicized words and figures and the omission of those in brackets:

"(*a*) The average size or denier of each skein, *tube, spool, cop, pirn or cone of rayon* as supplied by the seller, either bleached or unbleached, as found by test, shall not vary [more than 10 per cent] above or below the specified size or denier *more than:*

10 per cent for sizes finer than 150 denier, and
8 per cent for 150 denier or coarser.

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 26, Part I, p. 1071 (1926); also 1926 Book of A.S.T.M. Tentative Standards, p. 923.

[2] *Proceedings*, Am. Soc. Testing Mats., Vol. 25, Part I, p. 842 (1925); also 1926 Book of A.S.T.M. Tentative Standards, p. 934.

[3] *Proceedings*, Am. Soc. Testing Mats., Vol. 22, Part I, p. 973 (1922); also 1926 Book of A.S.T.M. Tentative Standards, p. 941.

[4] *Proceedings*, Am. Soc. Testing Mats., Vol. 25, Part I, p. 846 (1925); also 1926 Book of A.S.T.M. Tentative Standards, p. 944.

"(b) The average size or denier of each case of skeins, tubes, spools, cops, pirns, cones, or a beam warp of rayon yarn in the singles, either bleached or unbleached, as found by test, shall not vary [more than 5 per cent] above or below the specified size *more than:*

> *5 per cent for sizes finer than 150 denier, and*
> *4 per cent for 150 denier or coarser."*

The second has not been changed but is not recommended for advancement to standard because of work being done on some tests which indicate a probable revision within the year.

The third one has been standing unused for more than four years and will be revised by the new Sub-Committee on Raw Cotton.

TABLE I.

Item	Affirmative	Negative	Not Voting
I. NEW TENTATIVE STANDARDS			
1. Tentative Specifications for Tolerances and Test Methods for Certain Light and Medium Cotton Fabrics	66	3	38[a]
2. Tentative Specifications and Tests for Cuban (Jute) Raw Sugar Bags	40	0	67[a]
3. Tentative Methods for Identification of Textile Fibers and Their Quantitative Determination in Mixed Goods	53	0	20
II. REVISION OF STANDARDS			
4. Standard Methods of Testing Cotton Fabrics (D 39 - 24)	76	6	25[a]
5. Standard Specifications for Tolerances and Test Methods for Tire Fabrics Other than Cord Fabrics (D 122 - 25)	39	3	31
6. Standard Specifications for Tolerances and Test Methods for Cord Tire Fabrics (D 179 - 25)	39	1	33
7. Standard Specifications and Tests for Osnaburg Cement Sacks (D 205 - 25)	31	3	39
III. TENTATIVE STANDARDS ADVANCED TO STANDARD			
8. Specifications for Textile Testing Machines (D 76 - 25 T)	59	1	13
9. Specifications for Tolerances and Test Methods for Cotton Yarns, Single and Plied (D 180 - 25 T)	55	0	18
10. Specifications for Tolerances and Test Methods for Cotton Sewing Thread (D 204 - 25 T)	34	0	39
11. Specifications for Tolerances for Numbered Cotton Ducks (D 230 - 25 T)	47	1	25
12. Specfiations for Tolerances and Test Methods for Electrical Silk and Cotton Tapes (D 259 - 26 T)	32	0	41
13. Definitions and Terms Relating to Textile Materials (D 123 - 26 T)	59	2	12
IV. REVISION OF TENTATIVE STANDARD			
14. Tentative Specifications for Tolerances and Test Methods for Rayon (D 258 - 26 T)	31	0	42

[a] Submitted to letter ballot on October 28, 1926.

The fourth one is continued as tentative on account of work being done to clear up some moot points.

Sub-Committee II on Fabric Test Methods is working in conjunction with Sub-Committee III on Testing Machines to develop a standard instrument and standard method for measuring the thickness of piled and napped fabrics and felts.

Sub-Committee VIII on Humidity is working on the standardization of a method of determining the relative humidity of the air in testing laboratories and other places by the use of standardized instruments.

Sub-Committee XIII on Narrow Fabrics, since the completion of the Standard Specifications for Tolerances and Test Methods for

Electrical Silk and Cotton Tapes, has been working toward a segregation of the great variety of fabrics with which it has to deal so as to distribute the work to sub-sub-committees and may be expected to develop some important standards in the near future.

Sub-Committees XIV on Rope and Cordage and XVI on Asbestos Textiles are active and report progress but are not yet ready to report tentative standards but hope to do so within the next year.

The recommendations contained in this report have been submitted to letter ballot of the committee, consisting of 184 members, with the results shown in Table I.

This report has been submitted to letter ballot of the committee, which consists of 184 members, of whom 65 have voted affirmatively, one negatively, and 118 have refrained from voting.

Respectfully submitted on behalf of the committee,

K. B. COOK,
Secretary.

W. F. EDWARDS,
Chairman.

EDITORIAL NOTE

The proposed revisions of the Standard Methods of Testing Cotton Fabrics; Specifications for Tolerances and Test Methods for Tire Fabrics Other than Cord Fabrics; for Tolerances and Test Methods for Cord Tire Fabrics; and Specifications and Tests for Osnaburg Cement Sacks were approved at the annual meeting by a nine-tenths vote and were subsequently adopted by letter ballot of the Society on September 1, 1927. The specifications as revised appear in the 1927 Book of A.S.T.M. Standards, Part II.

The Tentative Specifications for Textile Testing Machines; for Tolerances and Test Methods for Cotton Yarns, Single and Plied; for Tolerances and Test Methods for Cotton Sewing Threads; for Tolerances for Numbered Cotton Ducks; and for Tolerances and Test Methods for Electrical Silk and Cotton Tapes were approved at the annual meeting and subsequently adopted by letter ballot of the Society on September 1, 1927. The Tentative Definitions of Terms Relating to Textile Materials were approved at the annual meeting, revised as recommended by the committee, and subsequently adopted by letter ballot of the Society on September 1, 1927. The specifications and definitions appear in the 1927 Book of A.S.T.M. Standards, Part II.

The proposed revisions of the Tentative Specifications for Tolerances and Test Methods for Rayon were accepted. The specifications as revised appear on page 1032.

The proposed definition of the term Loop Knot was accepted for publication as tentative and appears on page 1066.

The proposed Tentative Specifications for Tolerances and Test Methods for Certain Light and Medium Cotton Fabrics; Specifications and Tests for Cuban (Jute) Raw Sugar Bags; and Methods for Identification of Textile Fibers and Their Quantitative Determination in Mixed Goods, were accepted for publication as tentative and appear on pages 1039, 1041 and 1044, respectively.

REPORT OF COMMITTEE D-14

ON

SCREEN WIRE CLOTH

Committee D-14 has held two meetings during the past year, one in connection with the annual meeting in Atlantic City and the other at Philadelphia, on March 16, 1927.

The activities of the committee are at present mainly centered on the exposure tests of non-ferrous screen wire cloth which are taking place at the U. S. Bureau of Mines, Pittsburgh, Pa.; the U. S. Bureau of Standards, Washington, D. C.; the Bureau of Lighthouse Depot, Portsmouth, Va.; and the Panama Canal, Canal Zone. Subsidiary laboratory tests are also under way, all of which are under the supervision of Sub-Committee IV on Testing.

Regular quarterly reports are secured from all the exposure stations. No failures have as yet occurred in any of the tests and all the various grades of cloth closely resemble each other in appearance.

As an aid in studying the corrosive effect of the varying types of atmospheres encountered at the exposure localities arrangements have been made to obtain a daily analysis of the atmosphere for sulfur content at each station. The International Nickel Co. has furnished apparatus to each station and with the cooperation of the Weather Bureau and the other Government departments regular reports are received by the committee on the atmospheric sulfur content for the exposure locations. It is thought that these data may be of interest to other committees of the Society conducting exposure tests and Committee D-14 will gladly furnish information regarding these tests to other interested committees.

About a year ago, additional samples of each of the seven compositions of screen wire cloth under investigation were exposed at the Bureau of Standards at Washington in a fashion such that tension test specimens could be cut periodically both longitudinally and transversely from the samples. Specimens were taken from these exposures last fall and again this spring but so far there is not much variation in tensile strength between the specimens after exposure and their original values. More tests and time will be required to show differences.

Laboratory tests are being carried out in which a series of tension test specimens cut from the cloth are being subjected to salt spray and another series to gas corrosion of SO_2, CO_2 and air.

The committee recommends that in the Tentative Specifications for Non-Ferrous Insect Screen Cloth (B 50 – 25 T)[1] an additional mesh of cloth, namely 22-heavy, be provided for use in the tropics where fine openings are required. To provide for this addition and a change in the size of wire to be used for 18 (regular) mesh cloth the following revisions are recommended:

Section 3.—Change to read as follows by the addition of the italicized words and figures and the omission of those in brackets:

"Insect screen cloth shall be manufactured in [four] *five* weights or sizes of mesh as follows·

14-mesh *regular*
16-mesh *regular*
16-mesh heavy
18-mesh *regular*
22-mesh heavy"

Section 8.—Change Paragraph (*a*) to read as follows by the addition of the italicized words and figures and the omission of those in brackets:

"The nominal diameter of wires to be used for the various weights of standard insect screen cloth shall be in accordance with the following:

MESH	DIAMETER, IN.
14 *regular*	0.0119
16 *regular*	0.0113
16 heavy	0.0150
18 *regular*	*0.0100* [0.0106]
22 heavy	*0.0150*"

With these revisions it is recommended that the tentative specifications be continued as tentative.

The result of the letter ballot of the committee on these recommended revisions is as follows: Affirmative 14, negative 0, not voting 2.

This report has been submitted to letter ballot of the committee, which consists of 16 members, of whom 12 have voted affirmatively, one negatively, and 3 have refrained from voting.

Respectfully submitted on behalf of the committee,

R. W. WOODWARD,
Chairman.

W. H. BASSETT,
Secretary.

EDITORIAL NOTE

The proposed revisions of the Tentative Specifications for Non-Ferrous Insect Screen Cloth were accepted. The specifications as revised appear on page 737.

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 25, Part I, p. 587 (1925); also 1926 Book of A.S.T.M. Tentative Standards, p. 216.

REPORT OF COMMITTEE D-15
ON
THERMOMETERS

During the past year, the committee has accomplished a revision of another standard thermometer specification. The Standard Method of Test for Loss on Heating of Oil and Asphaltic Compounds (Serial Designation: D 6 – 20),[1] under the jurisdiction of Committee D-4 on Road and Paving Materials, has carried since its adoption a specification for a thermometer to be used in this test. The specification was considered inadequate in that the thermometer as specified had no fixed reference point, and was not drawn up in the standard form which has since been widely adopted for other thermometer specifications. The committee therefore recommended to Committee D-4 the revision of this specification. Such a revision is being presented by Committee D-4, with a recommendation for its immediate adoption.

The committee also had brought to its attention an inconsistency in the title of the Low Softening Point Thermometer specified in the standard methods for softening point of bituminous materials, Methods D 36 – 24 and D 61 – 24,[1] and in the Tentative Method for Float Test of Bituminous Materials (D 139 – 25 T)[2] and recommends that the title be changed to harmonize with the requirements of the specifications, namely, that the range given in the introductory text and under "Case" be changed to "-2 to + 80° C."

During the past two years, the committee has devoted much effort to the development of a new and acceptable thermometer for the distillation test of turpentine, described in the Standard Methods of Sampling and Testing Turpentine (D 233 – 26).[3] The instrument at present required for this test has been the subject of some criticism on account of great difficulty on the part of manufacturers to meet the specification requirements, but any revision must necessarily not disturb other factors of the test or distillation limits which have been established for turpentine. Proposed new types of thermometers have been prepared and compared under test conditions with the present required type of thermometer. While a large volume of data has been assembled, the committee is not quite prepared to make final recommendations but hopes to do so during the coming year.

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[1] 1924 Book of A.S.T.M. Standards.

[2] *Proceedings*, Am. Soc. Testing Mats., Vol. 25, Part I, p. 748 (1925); also 1926 Book of A.S.T.M. Tentative Standards, p. 586.

[3] A.S.T.M. Standards Adopted in 1926.

The proposed revision of the Loss on Heating Thermometer has been submitted to letter ballot of the committee with the following results: Affirmative, 10; negative, 0; not voting, 2.

This report has been submitted to letter ballot of the committee, which consists of 12 members, of whom 11 have voted affirmatively, none negatively, and one has refrained from voting.

Respectfully submitted on behalf of the committee,

W. H. FULWEILER,
Chairman.

C. S. REEVE,
Secretary.

EDITORIAL NOTE

The proposed revision of the loss-on-heating thermometer was adopted on the recommendation of Committee D-4 on Road and Paving Materials as a revision of the Standard Method of Test for Loss on Heating of Oil and Asphaltic Compounds, under the jurisdiction of that committee. See page 483.

REPORT OF COMMITTEE D-16
ON
SLATE

During the past year, the committee has held two meetings in addition to the annual meeting. Following the decision of the committee to hold some of its meetings in slate producing centers, the success of which was so strikingly demonstrated last year at the meeting in the Vermont-New York District, the regular fall meeting was, through the courtesy and cooperation of Lafayette College, Easton, Pa., held at that institution on the morning of November 18, 1926. Following the meeting there was an inspection tour of quarries in the afternoon and on the following day. This meeting and the tour arranged by the slate producers, was exceptionally well attended by committee members and architects and by members of the Lehigh Valley Engineers Society.

The second meeting of the committee was held in Philadelphia during the group meetings of the Society and was also well attended.

During the year one producer has resigned from the committee, making the membership 20, classified as 15 non-producers and 5 producers.

The details of the work of the committee can best be presented according to the work assigned to the various sub-committees as given below.

Sub-Committee I on Methods of Tests

The testing program which was started last year through cooperation of Rensselaer Polytechnic Institute, Lehigh University, Lafayette College and the U. S. Bureau of Standards has been completed and the results of comparative tests by these laboratories on five samples of slate are the subject of this report. The purpose of this testing program was to submit the Tentative Method of Test for Water Absorption of Slate (D 221 - 25 T) and the Tentative Methods of Flexure Testing of Slate (D 222 - 25 T) to a practical trial with a view of determining their weak points. In order to test the laboratory procedures it was planned to secure four identical sets of specimens from each of several quarry regions and distribute each set among the laboratories for comparative tests. Each producer called upon for specimens was asked to prepare the four sets from the same block of slate. This plan did not mature in all cases since some of the specimens from certain districts came from different quarries. For this reason the comparisons in the following tables are not as satisfactory as could be desired. However, it appears that the slates from those districts which submitted material from two or more different quarries are very uniform from one quarry to another and hence the results of tests may be assumed to be of value for the purpose in view.

The producers of those slates marked D and E in the tables were not equipped to finish the specimens as called for in the tentative test methods. The specimens of these slates were supplied with the natural cleavage faces. The specimens of slate D had sawed edges while those of slate E were sheared. The results on these slates in some cases, were rather unsatisfactory and some of the tests are of uncertain value. This raises an important question in regard to the test methods. In cases where it is desired to test a slate which cannot be readily obtained in the form specified and the testing laboratory is not equipped to prepare specimens, the present form of the tentative methods would not apply. Shearing a slab of slate which is $\frac{1}{4}$ or $\frac{3}{8}$ in. thick causes considerable fracturing near the cut and gives a jagged edge to the specimens. To shear out a specimen 1 by $1\frac{1}{2}$ by 12 in. would hardly be possible. Judging by the appearance of the specimens with sheared edges and the number of these which were broken in shipment one may conclude that the shearing is apt to cause considerable injury to the slate and test results on such may not do justice to the material. The cleavage faces are frequently uneven and splintered. In measuring the dimensions of such specimens the operator has to exercise his judgment. It is not always possible to get uniform bearing of such specimens on the knife edges in the flexure tests. Notwithstanding these undesirable features it may be necessary, in some cases, to make tests on slate specimens with both sheared edges and split faces. In such cases it seems advisable to increase the number of tests and eliminate the results which show evidence of defective specimens.

The slate samples have been designated as follows:

Slate A.—From the Bangor district of Pennsylvania. Samples tested by Laboratories Nos. 1, 3 and 4 were supplied by the North Bangor Slate Co. and those tested by Laboratory No. 2 were from the Amalgamated Slate Quarries Co.

Slate B.—From the Pen Argyl district of Pennsylvania. Samples tested by Laboratories Nos. 1 and 4 were supplied by the Jackson

Bangor Slate Co. and those tested by Laboratories Nos. 2 and 3 were supplied by the Structural Slate Co.

Slate C.—From the Slatington district of Pennsylvania. Samples tested by Laboratories Nos. 1, 3 and 4 were supplied by the Amalgamated Slate Quarries Co. and those tested by Laboratory No. 2 were supplied by the Structural Slate Co.

Slate D.—From Esmont, Virginia. All samples were supplied by the Blue Ridge Slate Co. with natural cleavage faces and sawed edges.

Slate E.—Sea Green slate from Vermont. All samples were supplied by the Norton Brothers of Granville, N. Y., with natural cleavage faces and sheared edges.

The testing laboratories are designated by numbers as follows:

Laboratory No. 1.—Rensselaer Polytechnic Institute;
Laboratory No. 2.—Lehigh University;
Laboratory No. 3.—Lafayette College;
Laboratory No. 4.—U. S. Bureau of Standards.

The tests made at Laboratory No. 1 were performed by instructors in the department of civil engineering under the supervision of Prof. T. R. Lawson. At Laboratory No. 2 the tests were made by Messrs. D. A. Heath and M. L. Hoffman, senior mining engineering students under the direction of Prof. M. O. Fuller. At Laboratory No. 3 the tests were made by Prof. C. W. MacDougal in cooperation with Prof. W. B. Plank. At Laboratory No. 4 one-half the tests on each set of specimens was performed by W. H. Sligh and the other half by D. W. Kessler.

Each laboratory was supplied with five sets of specimens each containing six specimens for absorption tests and twelve for flexure tests. The flexure test specimens were 12 by 4 by $\frac{3}{8}$ in. and the transverse strength and elasticity were both determined on these at the same operation. One-half these specimens were prepared with the grain parallel to the 12 by $\frac{3}{8}$-in. edge and are designated "A." The other half were prepared with the grain parallel to the 4 by $\frac{3}{8}$-in. edge and are designated "B." Two laboratories made absorption tests by both methods, that is, by the 48-hour immersion and the 8-hour boiling methods. In Table I the results of the first method are designated "*a*" and the second "*b*."

The mean values obtained by the four laboratories for each slate are given in the last and next to the last columns. The variation percentages given immediately below the average values of each laboratory were calculated from the deviation of each average from the corresponding mean values. For instance, the mean absorption value for slate A is 0.20 per cent. The average value obtained by Laboratory No. 1 for this slate was 0.26 per cent. The variation in this case was (0.26 − 0.20) 100 ÷ 0.20 = 30 per cent. In the case of the absorption tests the variations were all computed from the mean of the 48-hour immersion tests. In the flexure tests the two directions of grain were taken into account and the variations were computed for each condition.

TABLE I.—ABSORPTION TESTS ON SLATE BY FOUR TESTING LABORATORIES.

(Values expressed in percentages by weight.)

Test		Laboratory No. 1		Laboratory No. 2	Laboratory No. 3	Laboratory No. 4		Mean of A Values
		A	B	A	A	A	B	
Slate A	No. 1	0.29	0.27	0.15	0.20	0.18	0.17	
	No. 2	0.36	0.36	0.15	0.15	0.22	0.21	
	No. 3	0.31	0.26	0.00[a]	0.18	0.21	0.19	
	No. 4	0.30	0.25	0.21	0.22	0.18	0.16	
	No. 5	0.14	0.16	0.18	0.17	0.18	0.15	
	No. 6	0.20	0.18	....	0.15	0.25	0.22	
Average		0.26	0.25	0.17	0.18	0.20	0.18	0.20
Variation, per cent		30	25	15.0	10.0	0.0	10.0	
Slate B	No. 1	0.21	0.10	0.20	0.16	0.16	0.13	
	No. 2	0.17	0.10	0.08	0.15	0.16	0.14	
	No. 3	0.21	0.20	0.16[a]	0.14	0.17	0.14	
	No. 4	0.24	0.18	0.01[a]	0.16	0.15	0.15	
	No. 5	0.22	0.13	0.10	0.16	0.16	0.14	
	No. 6	0.23	0.18	0.07	0.16	0.16	0.13	
Average		0.21	0.15	0.08	0.15	0.16	0.14	0.15
Variation, per cent		40.0	0.0	46.7	0.0	6.7	6.7	
Slate C	No. 1	0.36	0.36	0.36	0.33	0.38	0.33	
	No. 2	0.45	0.45	0.29	0.33	0.37	0.32	
	No. 3	0.44	0.39	0.31	0.32	0.37	0.35	
	No. 4	0.44	0.46	0.32	0.35	0.39	0.32	
	No. 5	0.49	0.49	....	0.33	0.39	0.32	
	No. 6	0.49	0.49	....	0.34	0.37	0.32	
Average		0.44	0.44	0.32	0.33	0.38	0.33	0.37
Variation, per cent		18.9	18.9	13.5	10.8	2.7	10.8	
Slate D	No. 1	0.25	0.18	0.04	0.09	0.13	0.13	
	No. 2	0.19	0.17	0.04	0.27[a]	0.18	0.19	
	No. 3	0.30	0.30	0.17[a]	0.10	0.17	0.16	
	No. 4	0.22	0.27	0.05	0.09	0.16	0.15	
	No. 5	0.18	0.19	0.05	0.07	0.14	0.14	
	No. 6	0.35	0.25	....	0.07	0.13	0.14	
Average		0.25	0.22	0.04	0.09	0.15	0.15	0.13
Variation, per cent		92.3	69.2	69.2	30.8	15.4	15.4	
Slate E	No. 1	0.19	0.17	0.05	0.11	0.12	0.13	
	No. 2	0.33	0.22	0.07	0.13	0.13	0.10	
	No. 3	0.20	0.11	0.09[a]	0.14	0.11	0.10	
	No. 4	0.17	0.25	0.04	0.23	0.18	0.16	
	No. 5	0.15	0.15	0.18[a]	0.11	0.14	0.14	
	No. 6	0.23	0.15	0.06	0.10	0.13	0.12	
Average		0.21	0.18	0.05	0.14	0.13	0.14	0.13
Variation, per cent		61.5	38.5	61.5	7.7	0.0	7.7	

[a] Results not used in computing averages.

Table I gives the results of absorption tests. Greater variations were obtained in this test than in the others, and the magnitude of some indicates that further thought should be given to improving the methods. The average variation obtained in this series of tests was 29.8 per cent.

Table II gives the results of transverse strength determinations.

TABLE II.—MODULUS OF RUPTURE DETERMINATIONS ON SLATE BY FOUR TESTING LABORATORIES.

(Values expressed in pounds per square inch.)

Test		Laboratory No. 1		Laboratory No. 2		Laboratory No. 3		Laboratory No. 4		Mean Values	
		A	B	A	B	A	B	A	B	A	B
Slate A	No. 1	16 900	9 900	15 500	10 000	12 900	9 800	13 400	11 100		
	No. 2	14 000	9 700	9 800	7 800	12 200	6 600[a]	8 400	10 000		
	No. 3	14 800	10 600	15 900	9 100	15 000	8 000	11 800	10 000		
	No. 4	16 500	9 800	10 400	8 800	16 000	8 600	14 000	18 700		
	No. 5	9 100	9 900	9 200	9 500	17 400	9 800	9 200	9 600		
	No. 6	17 500	7 600	11 500	6 800	14 300	8 900	7 000[a]	8 600		
Average		14 800	9 600	12 000	8 700	14 600	9 000	11 400	11 300	13 200	9 600
Variation, per cent		12.1	0.0	9.1	9.4	10.6	6.2	13.6	17.6		
Slate B	No. 1	13 100	12 400	12 900	14 300	10 900	11 500	9 900	7 800		
	No. 2	12 000	13 600	14 400	15 100	14 100	13 200	13 600	8 300		
	No. 3	13 700	12 000	14 600	13 200	11 900	11 000	11 700	7 200[a]		
	No. 4	10 800	12 400	11 000	14 000	13 700	11 900	9 200	11 300		
	No. 5	13 600	10 900	14 500	12 400	11 400	12 900	11 300	13 200		
	No. 6	11 800	10 700	14 000	13 200	10 200	11 600	9 600	12 900		
Average		12 500	12 000	13 600	13 700	12 000	12 000	10 900	10 700	12 200	12 100
Variation, per cent		2.4	0.8	11.5	13.2	1.6	0.8	10.7	11.5		
Slate C	No. 1	13 700	10 800	13 000	9 100	13 600	7 600[a]	12 800	8 100		
	No. 2	13 500	10 200	14 300	8 200	15 700	9 100	12 000	7 800		
	No. 3	12 200	9 400	13 000	8 800	10 900[a]	8 900	13 600	7 800		
	No. 4	15 200	9 900	14 300	9 200	14 000	9 100	12 400	8 700		
	No. 5	12 600	8 700	.....	9 600	15 200	9 900	14 800	7 900		
	No. 6	13 000	.....	.....	.....	14 000	10 100	13 400	8 200		
Average		13 400	9 800	13 600	9 000	14 500	9 400	13 200	8 100	13 700	9 100
Variation, per cent		2.2	7.7	0.8	1.1	5.9	3.3	3.6	11.0		
Slate D	No. 1	7 300	9 000	9 800	7 600	10 500	8 900	7 300	8 200		
	No. 2	8 700	9 700	7 200[a]	11 100	9 200	9 000	7 500	6 400		
	No. 3	7 300	8 600	8 900	2 400[a]	8 500	7 300	8 400	8 900		
	No. 4	9 300	8 200	10 000	3 800[a]	10 000	8 400	9 400	9 700		
	No. 5	10 000	8 800	9 900	8 200	9 300	9 200	10 200	8 600		
	No. 6	8 300	8 500	9 000	.....	8 400	9 900	9 200	.....		
Average		8 500	8 800	9 100	9 000	9 300	8 800	8 700	8 400	8 900	8 800
Variation, per cent		4.5	0.0	2.2	2.3	4.5	0.0	2.2	4.6		
Slate E	No. 1	7 000	6 800	8 200	7 200	6 400	6 800	5 800	5 300		
	No. 2	9 600	7 100	4 600[a]	8 600	6 100	6 700	6 100	8 000		
	No. 3	5 000	6 100	7 000	8 800	7 100	7 400	.....	6 900		
	No. 4	5 400	6 800	7 500	7 200	6 100	7 200	9 300	9 200		
	No. 5	4 500	5 200	6 600	8 200	5 600	7 500	8 500	9 400		
	No. 6	.....	5 400	.....	7 100	.....	8 200	.....	8 100		
Average		6 300	6 200	7 300	7 800	6 300	7 300	7 400	7 800	6 800	7 300
Variation, per cent		7.4	15.1	7.4	6.8	7.4	0.0	11.8	6.8		

[a] Values not used in computing averages.

The average variation was 6.2 per cent and the greatest recorded was 17.6 per cent.

Table III shows the results of tests for modulus of elasticity. The average variation was 6.6 per cent and the highest was 16.9 per cent.

TABLE III.—MODULUS OF ELASTICITY DETERMINATIONS ON SLATE BY FOUR TESTING LABORATORIES.

(Value expressed in pounds per square inch.)

Test		Laboratory No. 1		Laboratory No. 2		Laboratory No. 3		Laboratory No. 4		Mean Values	
		A	B	A	B	A	B	A	B	A	B
Slate A..	No. 1	17 900 000	13 500 000	12 900 000	17 300 000	12 600 000	12 400 000	14 600 000	12 800 000		
	No. 2	20 700 000	17 500 000	16 000 000	8 400 000	12 300 000	12 600 000	13 900 000	13 000 000		
	No. 3	20 300 000	18 100 000	14 300 000	11 300 000	12 900 000	11 800 000	14 600 000	12 800 000		
	No. 4	12 800 000	15 700 000	18 900 000	11 900 000	13 000 000	12 500 000	11 200 000	11 800 000		
	No. 5	12 300 000	16 000 000	13 500 000	25 600 000[a]	14 300 000[a]	12 200 000	13 600 000	13 400 000		
	No. 6	15 600 000	12 700 000	12 900 000	23 100 000[a]	12 900 000	12 800 000	9 200 000[a]	15 500 000		
Average.........		16 600 000	15 600 000	14 700 000	12 200 000	12 700 000	12 400 000	13 600 000	13 200 000	14 200 000	13 400 000
Variation, per cent		16.9	16.4	3.5	8.9	10.6	7.4	4.2	1.5		
Slate B..	No. 1	15 400 000	15 800 000	12 900 000	12 700 000	15 600 000	12 600 000[a]	13 100 000	12 000 000		
	No. 2	13 400 000	13 200 000	13 200 000	14 800 000	18 300 000[a]	13 200 000[a]	15 100 000	13 100 000		
	No. 3	16 100 000	10 900 000	15 000 000	12 900 000	15 500 000	14 100 000	14 000 000	13 100 000		
	No. 4	13 500 000	12 100 000	13 900 000	15 100 000	19 300 000[a]	14 100 000	14 000 000	13 500 000		
	No. 5	16 600 000	11 700 000	14 600 000	13 300 000	15 100 000	14 400 000	15 900 000	13 400 000		
	No. 6	15 500 000	11 100 000	13 800 000	14 300 000	13 800 000[a]	14 300 000	14 000 000	13 500 000		
Average.........		15 100 000	12 500 000	13 900 000	13 800 000	15 400 000	14 200 000	14 400 000	13 100 000	14 700 000	13 400 000
Variation, per cent		2.7	6.7	5.4	3.0	4.8	6.0	2.0	2.2		
Slate C.	No. 1	13 400 000	12 300 000	18 200 000	12 100 000	12 800 000[a]	11 200 000[a]	14 000 000	11 800 000		
	No. 2	13 400 000	13 800 000	12 800 000	11 800 000	14 200 000	13 000 000	14 100 000	12 100 000		
	No. 3	16 100 000	11 900 000	13 800 000	10 500 000	15 900 000	13 500 000	13 700 000	11 900 000		
	No. 4	13 600 000	12 500 000	11 900 000	12 600 000	14 900 000	13 100 000	13 400 000	12 800 000		
	No. 5	13 900 000	11 800 000	....	11 600 000	14 500 000	13 500 000	13 900 000	12 400 000		
	No. 6	13 400 000	....	....	....	15 200 000	16 300 000[a]	15 300 000	12 500 000		
Average.........		14 000 000	12 500 000	14 200 000	11 700 000	14 900 000	13 300 000	14 100 000	12 200 000	14 300 000	12 400 000
Variation, per cent		2.1	0.8	0.7	5.7	4.2	7.3	1.4	1.6		
Slate D.	No. 1	12 900 000	10 500 000	17 400 000	12 100 000	18 800 000	13 400 000	15 000 000	15 000 000		
	No. 2	13 500 000	13 400 000	11 000 000	10 400 000	19 700 000	14 800 000	13 300 000	13 300 000		
	No. 3	13 800 000	13 500 000	9 400 000[a]	5 700 000[a]	15 700 000	17 800 000	14 700 000	14 400 000		
	No. 4	12 700 000	14 900 000	19 300 000	3 300 000[a]	18 800 000	15 300 000	15 600 000	15 700 000		
	No. 5	12 800 000	11 500 000	11 600 000	10 500 000	14 700 000	15 700 000	17 200 000	14 200 000		
	No. 6	14 400 000	16 400 000	11 300 000		13 900 000	16 600 000	17 100 000	....		
Average.........		13 400 000	13 400 000	14 100 000	11 000 000	16 900 000	15 600 000	15 500 000	14 500 000	15 000 000	13 600 000
Variation, per cent		10.7	1.5	6.0	19.1	12.7	14.7	3.3	6.6		
Slate E..	No. 1	13 400 000	12 100 000	9 600 000	7 200 000	....	....	11 300 000	13 000 000		
	No. 2	17 300 000	13 200 000	6 800 000[a]	9 700 000	....	....	12 500 000	13 000 000		
	No. 3	6 600 000	11 800 000	8 200 000	11 000 000	....	....	....	14 200 000		
	No. 4	8 800 000	14 400 000	13 300 000	11 400 000	....	....	15 000 000	13 000 000		
	No. 5	8 700 000	10 800 000	9 200 000	11 200 000	....	....	14 500 000	12 900 000		
	No. 6	....	10 200 000	....	8 800 000	....	....	....	13 300 000		
Average.........		11 000 000	12 100 000	10 000 000	9 900 000	....	....	13 300 000	13 200 000	11 400 000	11 700 000
Variation, per cent		3.5	3.4	12.3	15.4	....	....	16.7	12.8		

[a] Values not used in computing averages.

As already pointed out, some of the samples of slate designated by the same number were from different quarries, so it is evident that a part of the variation noted should be ascribed to a lack of uniformity in the materials. However, it is not logical to assume that the materials vary more in porosity than in strength and elasticity. It will be noted from Table I that five averages deviate from the respective mean values by more than 60 per cent. The inference from this is that the tentative methods for absorption should be made more rigid. It is worthy of note that the parallel tests of absorption made by two laboratories employing the regular 48-hour immersion tests and the 8-hour boiling tests on the same specimens, gave reasonably close agreement although the boiling test usually gave slightly lower results.

Laboratory No. 2 received two more sets of specimens than the other laboratories. The results on these are not included in the tables since they afford no comparisons. The average results on these will be given for record as follows:

WASHINGTON BIG BED (MATERIAL SUPPLIED BY THE AMALGAMATED SLATE QUARRIES CO., EASTON, PA.)

Percentage of absorption		0.19 per cent
Modulus of Rupture	(A)	12 700 lb. per sq. in.
	(B)	9 570 lb. per sq. in.
Modulus of Elasticity	(A)	14 000 000 lb. per sq. in.
	(B)	22 650 000 lb. per sq. in.

CHAPMAN HARD VEIN SLATE (SUPPLIED BY THE CHAPMAN SLATE CO., BETHLEHEM, PA.)

Percentage of absorption	0.11 per cent
Modulus of rupture[a]	14 770 lb. per sq. in.
Modulus of rupture[a]	8 700 lb. per sq. in.
Modulus of elasticity[a]	14 550 000 lb. per sq. in.
Modulus of elasticity[a]	22 500 000 lb. per sq. in.

[a] Direction of grain not known.

As a result of the cooperative testing program, the sub-committee has recommended a number of changes in the Tentative Method of Test for Water Absorption of Slate (D 221 - 25 T) and the Tentative Methods of Flexure Testing of Slate (D 222 - 25 T) which Committee D-16 presents herewith with the recommendation that they be approved and the methods as revised be continued as tentative.

Tentative Method of Test for Water Absorption of Slate (D 221 - 25 T).[1]—

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 25, Part I, p. 754 (1925); also 1926 Book of A.S.T.M. Tentative Standards, p. 787.

Sections 1 and 2.—Change Sections 1 and 2 covering test specimens from their present form: namely,

"1. Six representative specimens of the particular slate under consideration shall be submitted for this test. Each specimen shall be 6 by 6 in. measured along the cleavage planes and ¼ in. in thickness.

"2. The specimens shall be given a honed finish on all surfaces and edges."

to read as follows:

"1. *Size of Specimens.*—The specimens shall be 6 by 6 in. measured in the direction of cleavage and ¼ in. in thickness.

"2. *Preparation of Specimens.*—Preferably the specimens should be split to a thickness somewhat greater than ¼ in., sawed into 6-in. squares and finished on the faces and edges with a hone or fine abrasive to plane surfaces. Where this is not practical the slate may be split as nearly as possible to the desired thickness, sawed into 6-in. squares, and tested in this form.[a]

"3. *Number of Specimens.*—The number of specimens shall depend on the manner of preparation as follows:

Hone finished on faces and edges	6
Cleavage faces and sawed edge	9"

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[a] In testing slate shingles which have sheared edges, this type of specimen can be readily cut from the shingle with a hacksaw of the type in which the blade can be set at right angles to the frame.

Section 7.—Change from its present form: namely,

"The average absorption of the six specimens shall be reported as the absorption of the slate. If any individual value differs from the average of the six determinations by more than 25 per cent of the average value, the specimen shall be examined for defects, and if the result appears to be due to an imperfect specimen, it shall be discarded. The absorption shall then be reported as the average of the results obtained upon the remaining specimens. The report shall in all cases include the results of all determinations as information."

to read as follows:

"In general the average of all the tests shall be reported as the absorption of the slate. Individual determinations which differ by more than 25 per cent from the average of all the determinations may be disregarded when there is evidence that such results are of uncertain value. The absorption shall then be reported as the average of the remaining determinations, but all determinations shall be reported as information."

Tentative Methods of Flexure Testing of Slate (D 222 - 25 T).[1]—Add to the introductory notes a paragraph to read as follows:

"It is sometimes desirable to determine the modulus of rupture and modulus of elasticity of slate in one operation. The shape of specimens recommended for modulus of rupture under method *A* is not well adapted to elasticity measurements. However, a shape may be chosen which is adapted to both tests. That recommended under Method *B* will be found more convenient for use on roofing slates."

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 25, Part I, p. 756 (1925); also 1926 Book of A.S.T.M. Tentative Standards, p. 789.

Section 6.—Change the symbol M_f to R.

Replace the present method *B* covering Modulus of Elasticity, comprising Sections 8 to 12, with the following method:

B. Modulus of Rupture and Modulus of Elasticity

TEST SPECIMENS

8. *Size of Specimen.*—The specimens shall be 12 by 4 in. in the direction of cleavage and $\frac{3}{8}$ in. in thickness.

9. *Preparation of Specimens.*—The slate should preferably be split to a thickness somewhat greater than $\frac{3}{8}$ in. and sawed into specimens 12 by 4 in. These should be finished on the faces with a hone or fine abrasive to plane, parallel surfaces. Where this is not practical the slate may be split to as near the desired thickness as possible and the specimens sawed therefrom[a]. One-half the specimens from each sample shall be cut with the length parallel to the grain and the other half with the length perpendicular to the grain.

10. *Number of Specimens.*—The number of specimens shall depend on the method of preparation as follows:

Hone-finished faces and edges..............	3 each way of grain
Cleavage faces and sawed edges............	4 each way of grain

PROCEDURE

11. *Drying, Measuring and Testing.*—The specimens shall be dried, measured, and placed in a testing machine as described in method *A* on Modulus of Rupture. A deflectometer, capable of measuring accurately to 0.001 in., shall be used to indicate the deflections at the center of the span. The load shall then be applied at the rate of about 100 lb. per minute and deflection readings recorded for each 50-lb. increment.[b] The load w at which the specimens break shall be recorded to the nearest 5 lb.

12. *Computing Results.*—The modulus of rupture R shall be calculated from the breaking load w from the formula:

$$R = \frac{3\,w\,l}{2\,bd^2}$$

where the symbols have the same meaning as in method *A*.

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[a] In testing slate shingles which have sheared edges, this type of specimen can be readily cut from the shingle with a hacksaw of the type in which the blade can be set at right angles to the frame.

[b] It is not ordinarily satisfactory to set the deflectometer to zero when there is no load on the specimen. The best practice is to put a small initial load on the specimen, as 10 lb., and set the deflectometer to zero for this load. Since it is only the slope of the stress-strain curve that is desired this initial load does not affect the final result.

The load-deflection readings shall be plotted on cross-section paper to a convenient scale and a straight line drawn to represent as nearly as possible the average of the points plotted.[a]

If this line does not pass through the zero point a corrected line shall be drawn through the zero point parallel to the stress-strain curve. The modulus of elasticity shall be computed from the coordinates of some convenient point on the corrected line by means of the formula:

$$E = \frac{W'\,l^3}{4\Delta bd^3}$$

where W' = the load ordinate of this point;
Δ = deformation ordinate of same;
l = length of span in inches;
b = the width of the specimen in inches; and
d = the thickness of the specimen in inches.

13. *Reporting Results.*—In general the average of the results obtained for the specimens prepared with the length parallel to the grain shall be reported as the modulus of rupture and modulus of elasticity parallel to the grain. Likewise the average results obtained on the specimens cut with the length perpendicular to the grain shall be reported as the modulus of rupture and the modulus of elasticity perpendicular to the grain. In case an individual determination differs by more than 25 per cent from the average of its group it may be disregarded in computing the average if there is evidence that the determination was of uncertain value, but all determinations shall be reported as information.

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[a] Slate does not ordinarily show a yield point in the stress-strain curve.

SUB-COMMITTEE II ON ABRASIVE HARDNESS

The Sub-Committee on Abrasive Hardness has been giving study to the effect of abrasion, is continuing its investigations and expects to have a report at the next annual meeting of the Society.

SUB-COMMITTEE III ON HARDNESS AND WORKABILITY

No report has been submitted by the Sub-Committee on Hardness and Workability during the past year.

SUB-COMMITTEE IV ON ELECTRICAL SLATE

On the recommendation of the Sub-Committee on Electrical Slate the committee is submitting for publication as tentative, proposed Tentative Methods of Test for Determining the Insulating Qualities of Slate, as appended hereto.[1]

As submitted, these methods relate to factory or laboratory tests. The committee has been at work on the development of a quarry test designed to make possible the selection at the quarry of slate suitable for electrical purposes. This test may involve the use of a patented apparatus and the matter has accordingly been referred to the Executive Committee of the Society as required by the By-laws.

SUB-COMMITTEE V ON WEATHERING CHARACTERISTICS

The investigations of the Sub-Committee on Weathering Characteristics have been continued during the past year. With the cooperation of the Commandant of the Norfolk Navy Yard and of The International Nickel Co., at which yard tests are being conducted on the atmospheric sulfur content, copies of the monthly reports are furnished to the secretary of Committee D-16. These reports and the results which will be worked out from a comparison of them with the possible effect of such atmospheric conditions on slate, metals, etc., should prove very valuable. Studies of the chemical content of different slates and the effects of acids on these slates is also being studied.

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[1] See p. 978.—ED.

SUB-COMMITTEE VI ON NOMENCLATURE

Last year the committee submitted a definition for slate which, as then reported, met the approval of the members of Committee D-16 and which had been submitted to Committee E-8 on Nomenclature and Definitions for its suggestions. These suggestions have been received and the definition has been revised and has met with the approval of Committee E-8. The definition, as revised, is as follows:

Slate.—A microgranular crystallin stone derived from argillaceous sediments by regional metamorphism, and characterized by a perfect cleavage entirely independent of original bedding, which cleavage has been induced by pressure within the earth.

NOTE 1.—The essential mineral constituents are white mica (chiefly sericite) and quartz. Prominent accessory constituents are black mica (biotite), chlorite and hematite. Minor accessory constituents are carbonates, magnetite, apatite, clay, andalusite, barite, rutile, purite, graphite, feldspar, zircon, tourmaline and carbonaceous matter.

NOTE 2.—Igneous slates because of their rare occurrence and insignificant commercial importance are not covered in this definition.

This definition is now recommended by Committee D-16 for adoption as standard.

SUB-COMMITTEE VII ON COOPERATION WITH COLLEGES

The work of Sub-Committee VII is closely allied with that of Sub-Committee I and the results of its work are covered by the report of that sub-committee.

SUB-COMMITTEE VIII, EDITORIAL

To conform to the suggestions of Committee E-5 on Standing Committees, an Editorial Committee has been appointed.

SUB-COMMITTEE IX ON ABRASIVE SAND

At the last meeting of the committee a Sub-Committee on Abrasive Sand was appointed. This committee will study the sand used for rubbing slate, as it is felt that increased efficiency and economies can be effected by the careful selection of this sand.

The recommendations contained in this report have been submitted to letter ballot of the committee, which consists of 20 members, and 19 replies have been received as follows:

Items	Affirmative	Negative	Not Voting
I. REVISIONS OF TENTATIVE STANDARDS			
Tentative Method of Test for Water Absorption of Slate (D 221 - 25 T)	17	0	2
Tentative Methods of Flexure Testing of Slate (D 222 - 25 T)	17	0	2
II. PROPOSED NEW TENTATIVE STANDARD			
Tentative Methods of Test for Determining the Insulating Qualities of Slate	16	0	3
III. ADVANCEMENT OF TENTATIVE DEFINITION TO STANDARD			
Tentative Definition of the Term Slate (D 247 - 26 T)	18	0	1

This report has been submitted to letter ballot of the committee, which consists of 20 members, of whom 18 have voted affirmatively, none negatively and 2 have refrained from voting.

Respectfully submitted on behalf of the committee,

D. W. KESSLER,
Chairman.

D. KNICKERBACKER BOYD,
Secretary.

EDITORIAL NOTE

The proposed Tentative Methods of Test for Determining the Insulating Qualities of Slate were accepted for publication as tentative and appear on page 978.

The Tentative Definition of the Term Slate was approved at the annual meeting and subsequently adopted by letter ballot of the Society on September 1, 1927. The definition appears in the 1927 Book of A.S.T.M. Standards, Part II.

The proposed revisions of the Tentative Method of Test for Water Absorption of Slate; and Methods of Flexure Testing of Slate were accepted. The methods as revised appear on pages 972 and 974, respectively.

REPORT OF COMMITTEE D-17

ON

NAVAL STORES

From its establishment, Committee D-17 on Naval Stores has been engaged in the investigation of methods for the examination of rosin. The determination of dirt by two methods has been investigated and work has also been done on the determination of the softening and so-called melting point and on the determination of moisture and turpentine in rosin.

The work on the determination of softening, melting point, water and turpentine has not as yet developed procedures which the committee feels can be recommended for adoption by the Society. Th- work on the determination of dirt using toluol as a solvent, however, has been, it is felt, quite conclusive and because of this fact the committee is submitting the data which it has obtained on this method and a proposed tentative method for the determination of what it would term "toluol insoluble."

The method for the determination of toluol insoluble matter in rosin which the committee has worked with during the past year is as follows:

Preparation of Sample.—Immediately before the determination is to be made, powder the sample to pass a No. 10 sieve, mix thoroughly, and place in a wide-mouth bottle which the sample fills.

Determination.—Place 50 g. of the freshly powdered sample in a 300-cc. beaker and add 150 cc. of toluol, free from water and non-volatile residue. Dissolve the sample with the aid of heat and occasional shaking. When solution is apparently complete (no particle of rosin visible) filter at once through a 25-cc. porcelain Gooch crucible which has been previously prepared with a mat of pure well-washed asbestos such as is used for the determination of $BaSO_4$, and which has been finally washed thoroughly with the solvent used, dried in a boiling-water oven for 30 minutes, cooled in a desiccator, and weighed. If the rosin filtrate is not clear return it through the Gooch crucible until clear, finally washing the residue and the outside of the crucible free from rosin with additional hot solvent. Dry in a boiling-water oven for 1 hour. Cool in a desiccator, weigh, and calculate the percentage of dirt.

Under date of September 21, 1926, two samples were sent to the members of the committee for determination of the toluol insoluble by the method above outlined. The results reported are as follows:

COLLABORATOR	TOLUOL INSOLUBLE MATTER, PER CENT SAMPLE NO. 1	TOLUOL INSOLUBLE MATTER, PER CENT SAMPLE NO. 2
R. B. Rohrer	0.286	0.410
F. L. Roman	0.19	0.38
P. H. Walker	0.218	0.403
B. E. Kuyers	0.176	0.366
F. P. Veitch (Ward)	0.172	0.384
C. F. Speh (Odell)	0.22	0.37
E. B. Fasig	0.211	0.411
H. A. Gardner	0.18	0.39
E. B. Smith	0.183	0.378

Under date of February 4, 1927, two additional samples numbered 3 and 4 were sent to the members of the committee, upon which the following results were reported:

COLLABORATOR	TOLUOL INSOLUBLE MATTER, PER CENT SAMPLE NO. 3	TOLUOL INSOLUBLE MATTER, PER CENT SAMPLE NO. 4
P. H. Walker	1.11 1.10	0.171 0.168
R. B. Rohrer	1.10 1.08	0.180 0.177
F. J. Arthurs	1.08	0.184
E. W. Fasig	1.07 1.07	0.17 0.16
H. A. Gardner	1.08	0.16
B. E. Kuyers	1.11	0.15
F. L. Roman	1.06	0.15
E. B. Smith	1.07	0.17
E. J. Johnstone	1.099	0.162
F. P. Veitch (Smith)	1.08	0.168
A. M. Johnson	1.096	0.159
J. E. Lockwood (French)	1.07 1.09	0.166 0.168

The committee regards these results as so satisfactory that it feels warranted in recommending that the toluol method appended hereto[1] be accepted for publication as a Tentative Method of Test for the Determination of Toluol Insoluble Matter in Rosin.

This report has been submitted to letter ballot of the committee, which consists of 17 members, of whom 14 have voted affirmatively, 1 negatively, and 2 have refrained from voting.

Respectfully submitted on behalf of the committee,

C. F. SPEH,
Secretary.

F. P. VEITCH,
Chairman.

EDITORIAL NOTE

The proposed Tentative Method of Test for Determination of Toluol Insoluble Matter in Rosin (Chiefly Sand, Chips, Dirt and Bark) was accepted for publication as tentative and appear on page 895.

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[1] See p. 895.—ED.

REPORT OF COMMITTEE D-18

ON

NATURAL BUILDING STONES

ORGANIZATION

During the last two or three decades great changes have taken place in building construction practice with consequent marked changes in practice in structural design and in the use of the materials of construction. These changes have brought out the apparent dearth of reliable and up-to-date data of all sorts on most masonry materials, especially the lack of usable physical data on natural stone which would permit the designer to employ this material in an intelligent way in connection with modern types of building construction. To cite but a few examples of the deficiency in this respect, it may be stated that most hand-books and many text-books continue to give the weight of limestone for masonry use as around 160 to 165 lb. per cu. ft., whereas the actual average dry weight of limestone of the kind used for cut stone work, such as the Indiana Oolitic, is but 144 lb. per cu. ft. The weight of 160 lb. so often given applies to the hard crystallin limestone rock formations that are but rarely used for cut stone work but which are used for concrete aggregate.

Many building codes still retain antiquated provisions governing the use of stone which by the very nature of their inadequacy are violated in the approval of plans and the issue of permits for buildings designed by leading architects and engineers. The bonding requirements of many codes are both impractical and wasteful and often impossible for light enclosure walls in connection with modern skeleton frame construction.

The change from masonry wall construction of moderate heights to skeleton frame construction, where a comparatively light enclosure wall or envelope of masonry is carried on the structural frame, has introduced new problems requiring a better knowledge of the physical properties of the materials employed, since this envelope of masonry is so frequently composed of a comparatively thin facing of cut stone anchored to the frame and to the backing of some other material, such as brick, clay tile, or concrete blocks.

The movements and tremors that are known to occur in tall structures, especially those due to temperature changes, sun and wind action, just as much as weathering and frost action, are all important points to the designer of modern structures. A knowledge of a material's thermal properties, expansion and fatigue is necessary to the architect or engineer who is called upon to design and build a structure twenty, thirty or more stories in height. He is interested in knowing more about the relative action of various facing materials in composite wall construction and of the most efficient and economical methods of supporting, bonding and anchoring these facings to the structural frame.

The apparent need for a more accurate and complete knowledge in reference to the properties of natural building stone led to the organization of Committee D-18, the first move being prompted by the former Indiana Limestone Quarrymen's Association. After discussing the possibility of forming a committee with the several branches of the stone industry the organization of the committee was authorized. An organization meeting was held in New York City on March 30, 1926, with a representative group of producers and consumers in attendance. Mr. Francis Y. Joannes, representing the American Institute of Architects, was elected chairman, W. M. Greig, civil engineer, vice-chairman, and H. S. Brightly, director, Architects Service Bureau, Indiana Limestone Co., secretary. The "Non-Producer" group of the committee consisted of architects and engineers and representatives of agencies interested in building construction. In the "Producer" group of the committee the granite and limestone branches of the stone industry were included, to which has since been added the marble producers. It is hoped to soon include also the only branch of the natural stone industry not now represented, the sandstone interests, and to otherwise broaden and round out the representation on the "Producer" half of the committee, as well as to interest other important "consumer" interests in cooperating with the work of this committee.

A program to govern the work of the committee, prepared by a special committee on scope, was adopted at the organization meeting, as follows:

1. Uniform nomenclature applying to the stone industry.
2. Physical and chemical properties as affecting structural stability and weathering.
3. Effect of external agencies, including working processes, on the appearance and durability of building stone.
4. Prescribed tests and standard methods of testing.
5. Thermal properties and fatigue of stone and the effect of various forms of backing.

6. Effect of various materials and processes used in handling, setting and cleaning on the appearance and weathering of building stone.

7. Development of proper specification requirements:
    - (*a*) Granite;
    - (*b*) Limestone;
    - (*c*) Sandstone;
    - (*d*) Marble;
    - (*e*) Other Stones.

8. Names and definitions for stone finishes.
9. Structural integrity of stone after subjection to fire.
10. Preservation and maintenance of old stone structures.
11. Resistance to abrasion under various conditions of usage.

COMPILATION OF DATA

Much work has already been done in compiling the existing data on building stone in connection with various investigations that have been under way for some time at the U. S. Bureau of Standards. In addition to this, Mr. Loughlin, the chairman of the Sub-Committee on Data, has made a rather extensive study of building stone deposits in his capacity as geologist with the U. S. Geological Survey. Mr. Peffer, a member of the Sub-Committee on Data, has assembled considerable data from the chemical viewpoint, and Mr. Dutton, with the assistance of Mr. D. W. Kessler, Engineer Physicist of the Bureau of Standards, has assembled a considerable amount of the existing data on tests, both physical and weathering tests.

FUTURE PLANS

The future plan of the committee is to first complete the compilation of a bibliography of present sources of data on building stone and to study the existing data, assembling this in a usable form. With this as a guide a program of investigation and tests will be developed that will furnish the information needed to establish specific standards and other requirements governing the safe, proper, efficient and economical use of natural stone in all forms of building construction.

A special feature is to be made of the study of thermal properties, expansion and fatigue and the relation, or relative properties of the different types of building stone when used in connection with the other materials of construction, to which such materials must be applied or attached, or with which they must be combined in masonry. Another feature and one of great importance is the way in which the appearance or weathering of building stone may be affected by other materials with which it is built in contact, or with which it may be treated in the process of waterproofing or cleaning. This is represented by item No. 6 of the program given above.

This report has been submitted to letter ballot of the committee, which consists of 20 members, of whom 19 have voted affirmatively, none negatively, and one has refrained from voting.

Respectfully submitted on behalf of the committee,

FRANCIS Y. JOANNES,
Chairman.

H. S. BRIGHTLY,
Secretary.

REPORT OF COMMITTEE E-1

ON

METHODS OF TESTING

The past year, in the activities of Committee E-1 on Methods of Testing, has been one of continued development of its sub-committee organization so as to adequately cover the field of methods of testing to properly study methods from a fundamental standpoint. This development continues to take the form of organizing sub-groups (designated sections) of the various sub-committees, each group or section handling one specific test. For example, the Sub-Committee on Mechanical Testing, under the chairmanship of H. F. Moore, in addition to the Section on Testing Thin Sheet Metals, which has been in existence for the past two years, has now organized a Section on Tension Testing, under the chairmanship of R. L. Templin, and a Section on Compression Testing, under the chairmanship of H. H. Schofield. It has in process of organization a section on flexure testing and is considering the organization of a section on bend testing for ductility.

In organizing these sections it has been the practice to secure a small nucleus group of interested and specially qualified individuals, together with the representatives of the standing committees serving on the parent sub-committee who would be interested in the work of the section in question. Invitation is extended to the members of the Society to serve as unofficial members of the section should they so desire, and to cooperate in whatever work and investigations that may be undertaken.

In initiating the work of these sections in each instance it has been suggested that the section first of all make a thorough analysis of the tests under its jurisdiction, looking toward the development of a discussion or presentation of the fundamental principles involved in the tests, which might appropriately form a part of a general compendium on testing.

Similarly, the Sub-Committee on Size and Shape, under the chairmanship of J. P. Hubbell (appointed to succeed F. G. Breyer) now has a Section on Sub-Sieve Sizes, under the chairmanship of J. P. Hubbell, and is organizing a section on coarse screens, under the chairmanship of F. H. Jackson. Similar sectional organization has been suggested to the Sub-Committee on Consistency, Plasticity, etc., under the chairmanship of E. C. Bingham (appointed to succeed W. E. Emley).

The sub-committees for the most part have been quite active, but as the reports on the activities of the various sub-committees will indicate, as presented later in this report, much of the work has been of such a nature that final reports are not yet forthcoming. This report is accordingly essentially one of progress, although the progress made is quite substantial. The committee has held only one meeting during the year, on April 13, 1927, at which action was taken on some of the tentative standards under the jurisdiction of the committee, and the work of the various sub-committees was reviewed. One new sub-committee has been organized during the year, namely, the Sub-Committee on Chemical Composition under the chairmanship of G. E. F. Lundell. This brings the total number of sub-committees up to eight, as follows:

Sub-Committee on Mechanical Testing;
Sub-Committee on Impact Testing;
Sub-Committee on Volatility;
Sub-Committee on Plasticity, Consistency, etc.;
Sub-Committee on Determination of Water;
Sub-Committee on Size and Shape;
Sub-Committee on Methods for Density;
Sub-Committee on Chemical Composition.

While as many of the tests as possible are assigned to regular sub-committees, organizing new sub-committees where the need develops, there are many descriptions of tests in the standards and tentative standards of the Society where only one, or at most several, descriptions are involved and where very little correlation between tests would seem to be necessary. The work of seeing that these tests are in satisfactory form would appear to be largely an editorial matter. It is primarily the handling of these tests that prompted the organization of the Editorial Committee of the Advisory Committee. As mentioned in the 1926 report, this Editorial Committee may function along several lines: (1) It may review the various miscellaneous methods to see that the requirements of the methods are clearly and accurately stated, that no provisions are inconsistent with other methods of the Society, and that the form and arrangement of the methods are in accordance with the Society's requirements as given in the Regulations Governing the Form but not the Substance of Standards; (2) it may make a fundamental study of individual methods of test, calling upon outside experts if need be, and present the results of this study for general information. (3) In addition to making this fundamental study and report, a suggested general method of test may be prepared which will serve as a master general method, either to be submitted as a standard of the Society to be incorporated by reference in other standards involving the test, or as a method to be used for comparison purposes as a form for the individual standing committees to follow.

The Editorial Committee has continued its activities during the past year along these three lines. In its work during the past two years it has developed that in a number of instances separate procedures are prepared by separate committees for what would appear to be the same determination. These procedures should be harmonized and they are accordingly being compared one with another to learn if any of the discrepancies in the separate descriptions can be eliminated.

As an instance of this work of making comparisons of methods having some similarity, the attentions of Committee D-5 on Coal and Coke and of Committee C-8 on Refractories were called to the methods prepared by these committees covering the fusibility of coal ash and the softening point of fire-clay brick, respectively. It was suggested to these two committees that if a study were made of the differences in these two procedures possibly a number of them could be eliminated. Mr. C. W. Parmelee reviewed this question for Committee C-8 and Mr. A. C. Fieldner for Committee D-5, and the results of their review were submitted to the Editorial Committee and a comparison was made. From the statements submitted it would appear that, although some unification might be effected there would be little advantage in making the requirements for the fusion test of refractories conform with the requirements for the fusion test of coal ash. However, it would appear that it would be desirable to have some statement prepared on fusion testing in general, similar to that on refractive index submitted with last year's report, including with this the two methods in question and possibly other similar methods, prefacing the whole with a general discussion of the reasons for making the fusion tests and the particular pitfalls which anyone taking up such tests for the first time should guard against.

In this particular instance, apparently no complete unification is practical. However, the committee feels that in many instances comparisons such as this will make evident the many differences in non-essentials in descriptions of methods and places where the methods can and should be harmonized.

Specific studies have been assigned to the several members of the committee. The methods for solubility in organic solvents are being studied by Mr. Fulweiler. The methods for acidity, saponification, unsaponifiable matter, polymerization, iodine number, are being studied by Mr. J. P. Hubbell, who for the past two years has acted for Mr. F. G. Breyer on the Editorial Committee, and more recently has been appointed to succeed Mr. Breyer as a member of the Editorial Committee. In carrying on this work Mr. Hubbell has been in communication with a number of experts in the testing of animal, vegetable and mineral oils and he has received from them comments on the possibility of preparing methods applicable to these oils. The results of his study on the acid number of oils, fats and waxes were presented at the meeting of Committee E-1 but further criticism will be solicited before this statement is published.

During the year the committee again called the attention of standing committees to its general recommendations on the preparation of test methods, published in the Report of Committee E-1 for 1925.[1] The committee is gratified by the improvement evident in the form of the methods submitted as tentative in recent years over the form of the older methods. The committee feels, however, that still more can be accomplished in the way of securing more satisfactory descriptions complete in all detail, including sections on scope, on limitations of accuracy to be expected, etc.

SUB-COMMITTEE ON MECHANICAL TESTING

Mention has already been made of the organization under the Sub-Committee on Mechanical Testing (H. F. Moore, chairman) of Sections on Tension Testing and on Compression Testing. The former section, under the chairmanship of R. L. Templin, has held an organization meeting and has made preliminary plans for its work. The latter section, under the chairmanship of H. H. Schofield, plans to start active work this fall. The sub-committee has asked Messrs. H. A. Anderson and J. R. Townsend to prepare a preliminary report on the possibility of drawing up standards for hardness testing other than the Brinell test.

The Section on Testing of Thin Sheet Metals, under the chairmanship of H. C. Knerr, has continued its vigorous work and this year has prepared requirements covering a recommended tension test specimen for thin sheet metals. These requirements are being recommended for incorporation in the Tentative Methods of Tension Testing of Metallic Materials as mentioned below. A tabulation of foreign practice in the design of tension specimens of thin sheet metals has been prepared by this section and is presented as an appendix to this report.

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 25, Part I, p. 400 (1925).

On the recommendation of this sub-committee, Committee E-1 presents the following recommendations:

1. That the Tentative Method of Verification of Testing Machines by Means of an Elastic Calibration Bar (E 4 - 26 T)[1] be modified as follows and that the method as revised be adopted as standard:

(*a*) The term "bar" wherever it occurs be replaced by the term "device."

(*b*) In Section 6, change the first two sentences to read as follows by the addition of the italicized words:

> "The strainometer *for elastic calibration devices which employ elastic bars in axial tension or axial compression* shall be so designed as to indicate the average elongation or compression of the bar. *For any elastic calibration device* it shall be sufficiently sensitive to indicate a change of 0.25 per cent of the minimum load in the loading range of the bar."

2. That the Tentative Methods of Brinell Hardness Testing of Metallic Materials (E 10 - 25 T)[2] be advanced to standard.

3. That the Tentative Methods of Tension Testing of Metallic Materials (E 8 - 25 T)[2] be revised by the incorporation of requirements for a test specimen for testing thin sheet metal, the detailed revisions being indicated below.

4. That the Tentative Methods of Compression Testing of Metallic Materials (E 9 - 25 T)[2] be revised to make the wording on speed of testing machine consistent with that of the Tentative Methods of Tension Testing of Metallic Materials.

The sub-committee had also recommended the advancement to standard of the Tentative Definitions of Terms Relating to Methods of Testing (E 6 - 25 T)[2] subject to the approval by Committee E-8 on Nomenclature and Definitions. Committee E-8 has recommended that the advancement to standard of these definitions be deferred and the definitions are accordingly being continued as tentative.

The Tentative Methods of Tension Testing of Metallic Materials (E 8 - 25 T) and the Tentative Methods of Compression Testing of Metallic Materials (E 9 - 25 T) are continued as tentative in view of the work under way by the sections on Tension Testing and Compression Testing, looking toward the development of general methods of tension testing and compression testing, respectively.

Proposed Revisions of the Tentative Methods of Tension Testing (E 8 - 25 T).[2]—

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 26, Part I, p. 1086 (1926); also 1926 Book of A.S.T.M. Tentative Standards, p. 979.

[2] *Proceedings*, Am. Soc. Testing Mats., Vol. 25, Part I, pp. 872, 854, 867 and 879 (1925); also 1926 Book of A.S.T.M. Tentative Standards, pp. 972, 954, 967 and 982.

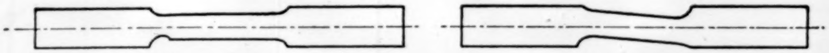
Section 3.—Change the first sentence to read as follows by the addition of the italicized words:

> "The tension test specimen shown in Fig. 1 is recommended for plate, shape and flat material *having a thickness of $\frac{1}{4}$ in. or over.*"

Omit the last sentence of the note to this section, reading as follows:

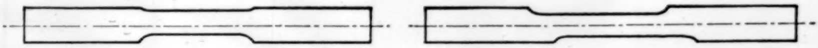
> "Up to the present time it has not been possible to fix a definite line between plate material and sheet material."

Add three new sections designated Sections 4, 5 and 6, respectively, to read as follows, renumbering the subsequent sections accordingly:



(*a*) Ends not Symmetrical with Reduced Section.

(*b*) Two Sides of Reduced Section not Symmetrical.



(*c*) Ends not Parallel to Reduced Section.

(*d*) Narrow Width Due to "Hogging In" of the Cutter.

FIG. 1.—Common Errors in Preparation of Plate or Sheet Metal Test Specimens.

"4. For tension tests of wrought ferrous and non-ferrous metal in the form of plate, sheet, flat wire,[1] strip,[1] band,[1] and hoop[1] without respect to width,[1] length, grade or method of manufacture, and having a thickness from 0.01 in. to 0.250 in., the test specimen described in Sections 5 and 6 is recommended.

NOTE.—This specimen may also be used in tests of material cut from tubing.

"5. The specimen blank shall be cut from the material to be tested, having its length in such direction relative to the material as may be specified. The specimen blank shall conform to the dimensions shown in the following table:

METHOD OF CUTTING LONG EDGES OF BLANK	NOMINAL THICKNESS OF MATERIAL, IN.	MINIMUM WIDTH OF BLANK, IN.
Sheared	Up to $\frac{1}{8}$, incl.	$\frac{3}{4}$
Sheared	Over $\frac{1}{8}$ to $\frac{1}{4}$, incl.	1
Sawed[a]	Up to $\frac{1}{4}$, incl.	$\frac{3}{4}$

[a] Or otherwise machined without severely straining the metal.

Blanks cut with a torch shall not be used unless all metal affected by such cutting is removed by machining.

"6. Figure 2 shows the form of the finished specimen recommended for thin sheet metals. The reduced section of the specimen shall be machined in such a manner as to avoid leaving severe machining strains in the material. It is essential that the reduced section and the ends of the specimen be symmetrical with respect to the longitudinal axis of the specimen.[1]

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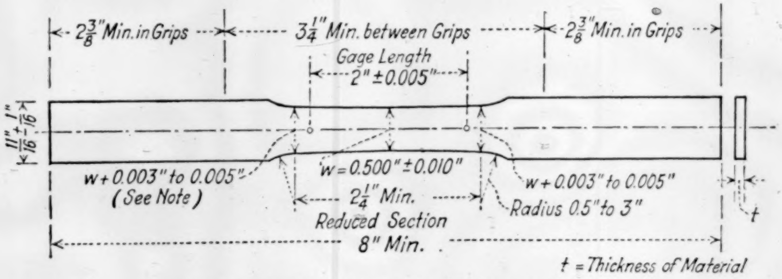
[1] It is to be noted that the recommended specimen cannot be used for flat wire, strip, band, or hoop material whose width is less than the end width of the specimen itself.

"In Fig. 2, the 2-in. gage length should be laid off with a tolerance in length of ±0.005 in."

REPORT OF SUB-COMMITTEE ON IMPACT TESTING

The Sub-Committee on Impact Testing, under the chairmanship of E. B. Smith, had hoped to receive during the year criticisms and comments on the proposed methods of impact testing of metallic materials submitted as information with the 1926 report of Committee E-1. A more determined effort will be made to secure comments during the coming year so that the methods may be suitably revised and possibly submitted as tentative methods next year.


$2\frac{3}{8}$" Min. in Grips
$3\frac{1}{4}$" Min. between Grips
$2\frac{3}{8}$" Min. in Grips
Gage Length
2" ±0.005"
$\frac{11}{16}$" ± $\frac{1}{16}$"
w + 0.003" to 0.005"
(See Note)
w = 0.500" ± 0.010"
w + 0.003" to 0.005"
$2\frac{1}{4}$" Min.
Reduced Section
Radius 0.5" to 3"
t
8" Min.
t = Thickness of Material

Note: Gradual Taper from Ends of Reduced Section to Middle.
All Machining Dimensions are Shown below and Testing Dimensions above Specimen.

FIG. 2.—Standard Tension Test Specimen for Thin Sheet Metals.

There seems to be some activity awakening along the line of fundamental research in impact, which will in time aid in the establishing of some definite laws concerning effect of impact loads on materials and structures. The most important impact problem, and the one probably of most general interest, is the determination of the effect of impact forces in tension, compression, shear, and cross-bending in comparison to the same static forces. The sub-committee suggests this line of research work to all laboratories having the proper facilities.

SUB-COMMITTEE ON CONSISTENCY, PLASTICITY, ETC.

Mr. E. C. Bingham has accepted the chairmanship of the Sub-Committee on Consistency, Plasticity, etc., to succeed Mr. W. E. Emley, but so recently that there has been no opportunity for the sub-committee to develop the subject before it, beyond that reported last year. The report presented last year is being reviewed and the sub-committee has also been requested to make a study of the present methods of the Society dealing with consistency and related properties with the idea of bringing these methods in line with the sub-committee's recommendations. The sub-committee has also had referred to it the subject of determining the viscosity or consistency of fibrous filled bituminous cements.

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[1] For all specimens for flat metallic materials, both for thin sheet and for thick plate, it is important to so machine the specimen as to avoid the conditions shown in Fig. 1.

SUB-COMMITTEE ON VOLATILITY

As a result of the activities of the Sub-Committee on Volatility, A. W. Dow, chairman, a short-necked flask, designated as the E-1 flask, has been developed and has been accepted by Committee D-4 on Road and Paving Materials and Committee D-7 on Timber for use with their methods of test for distillation. Considerable work has been carried out in these committees on the methods and procedure with this flask, that is, as to the position of the thermometer, rate of distillation, shape of hood for protecting the flask and other minor parts. This has entailed considerable collaborative work in both Committees D-4 and D-7 and, as a result, new methods are being submitted to replace the existing standard methods. The work of revision, based on collaborative work, participated in by a number of laboratories throughout the country, is necessarily slow but it is felt that considerable progress is being made and in the end the distillation methods will have been very much simplified and improved.

Committee D-2 on Petroleum Products and Lubricants is this year recommending the advancement to standard of the Tentative Method of Test for Distillation of Gasoline, Naphtha, Kerosine, and Similar Petroleum Products (D 86 - 26 T) and the Tentative Method of Test for Distillation of Natural Gas Gasoline (D 216 - 25 T). On the recommendation of the Sub-Committee on Volatility this advancement to standard is being approved by Committee E-1.

SUB-COMMITTEE ON DETERMINATION OF WATER

During the past year, the Sub-Committee on Determination of Water, under the chairmanship of W. H. Fulweiler, has taken up two matters of some interest. A discrepancy was brought to the sub-committee's attention in the dimension of the copper still specified in the Standard Method of Test for Water in Petroleum Products and Other Bituminous Materials (D 95 - 24) and in the methods for determination of water described in the Standard Methods of Sampling and Analysis of Creosote Oil (D 38 – 24). The sub-committee looked into the history of the copper still so as to learn which dimension might be considered authoritative. The sub-committee points out that this is an interesting example of the carelessness existing at times in the drafting of sketches, etc., in preparing methods of test, for it was through just such carelessness that the discrepancies arose. Evidently, in order to clarify the situation, it would be necessary that the dimensions be given with tolerances in order to cover the various pieces of apparatus that are in use and measurements have been secured of a rather large number of stills that are in use which show that the outside diameter varies from 3.5 to 3.88 in. and the height of the flange from the bottom varies from 5.75 to 6.25 in., one still having a height of 6.38 in. Apparently, suitable dimensions would be 3.7 in. ±0.2 in., and 6.0 in. ±0.25 in., and the committees interested, namely, Committees D-2 on Petroleum Products and Lubricants, D-4 on Road and Paving Materials and D-7 on Timber, are being asked to make this correction in their methods.

It was further brought to the attention of the sub-committee that where the Standard Method of Test for Water in Petroleum Products and Other Bituminous Materials (D 95 – 24) is used in the determination of water or moisture in wood, that the solvent employed has some effect on the results obtained. There is a difference of nearly 1 per cent in the moisture figures obtained on sawdust when solvents boiling at 80° C. and 175° C. are used, the solvent of higher boiling point giving the higher percentage of moisture. This matter is receiving the further consideration of the sub-committee.

SUB-COMMITTEE ON SIZE AND SHAPE

The Sub-Committee on Size and Shape has until recently been under the chairmanship of F. G. Breyer. Mr. Breyer has found it necessary to relinquish this chairmanship and accordingly J. P. Hubbell, who had acted for Mr. Breyer in handling the work of this sub-committee, has been appointed the chairman.

The work of the sub-committee has been handled by two sections, one on Sieves and Screens, the other on Sub-Sieve Sizes. The Section on Sieves and Screens had developed Specifications for Sieves for Testing Purposes (E 11 – 26) adopted as standard last year, and since then has been engaged in promoting the use of these specifications. This has involved not only the forwarding of the specifications to cooperating organizations but also suggesting to the various standing committees of the Society that they bring all references to sieves in line with the standard specifications.

The Section on Sub-Sieve Sizes has been engaged in (1) the collection of methods in use by the different laboratories in the measurements of extremely fine materials, and (2) conducting a series of measurements by these laboratories using their own methods and any other proposed methods for which they have the required equipment. The various types of equipment involved are the following:

1. Microscope with eyepiece micrometer.
2. Photomicrographic outfit.
3. Slit ultra microscope or dark ground illuminator.
4. Device for measuring intensity of light scattered by a suspension.
5. Device for measuring the light-obscuring power of a suspension.
6. Thompson classifier.
7. Air classifier for material finer than 45 microns.
8. Device for measuring the settling rate of fine material from suspension.

A number of methods are being tried out on the following materials:

For Average Particle Size Measurement:

Zinc Oxide (3 samples) one in the neighborhood of 0.2 micron, one 0.4 micron and one about 1 micron;
Zinc dust running about 3 to 4 microns;
Gas Black; and
Lampblack.

For Classification into Various Size Ranges:

Marble dust and anhydrous gypsum ground to pass a 74-micron (No. 200) sieve;
Red Lead;
Ground cement rock;
Coal dust.

The section already has in its hands reports from three of the cooperators giving complete descriptions of the methods they used and measurements on a number of samples sent out by the committee. Four or five of the other cooperators are at present busy making similar measurements, and their reports are expected within the next few months. The work is of the kind which cannot be hurried through. However, the varied interests represented by the different working members and the interest that is being shown encourages the section to believe that its work will be a real contribution to the subject of particle size measurement, and that one or more standard methods for making such measurements will be ready for submission to Committee E-1, and the Society as a whole, either next year or the year after.

A section is now being organized under the chairmanship of F. H. Jackson, to effect, if possible, some unification in screens having openings larger than No. 4 of the present Standard Specifications E 11 - 26. There is at present no agreement as to whether square-mesh or round-hole openings should be used in making mechanical analyses. This is especially true in the highway field and has caused considerable confusion. The personnel of the new section will include representatives of the several standing committees of the Society concerned, representatives of the producing interests, such as the National Sand and Gravel Association, the National Crushed Stone Association and the National Slag Association, and the representatives of manufacturers of screens. It is expected that organization will be effected in the near future.

SUB-COMMITTEE ON METHODS FOR DENSITY

The Sub-Committee on Methods of Test for Density, A. T. Goldbeck, chairman, has been engaged during the past year in work of a preliminary nature, so that it will be in a position to push forward its work rather expeditiously during the coming year. A list of references to the standards of the Society in which tests having to do with density are described, has been prepared. A meeting of the committee will be held in the near future to consider a detailed plan of procedure based upon the suggestions thus far received from the various members of the sub-committee.

SUB-COMMITTEE ON CHEMICAL COMPOSITION

As mentioned earlier in the report, the Sub-Committee on Chemical Composition, under the chairmanship of G. E. F. Lundell, has been but recently organized. The complete personnel of this sub-committee is as follows:

Comm. A-1	M. E. McDonnell	Comm. C-3	F. B. Lysle
A-2	H. E. Smith	C-7	E. E. Eakins
A-3	J. T. MacKenzie	C-8	L. J. Trostel
A-7	H. L. Campbell	C-9	D. A. Abrams
A-9	G. E. F. Lundell	C-11	H. E. Brookby
B-2	G. E. F. Lundell	D-1	F. W. Smither
B-4	T. R. Cunningham	D-11	S. Collier
C-1	Louis Anderson, Jr.		

The recommendations appearing in this report have been submitted to letter ballot of the committee with the following results:

Items	Affirmative	Negative	Not Voting
I. ADVANCEMENT TO STANDARD OF TENTATIVE METHODS			
1. Tentative Method of Verification of Testing Machines by Means of an Elastic Calibration Bar (E 4 – 26 T), as revised	30	0	17
2. Tentative Methods of Brinell Hardness Testing of Metallic Materials (E 10 – 25 T)	28	0	19
II. REVISION OF TENTATIVE METHODS			
3. Tentative Methods of Tension Testing of Metallic Materials (E 8 – 25 T)	18	0	29
4. Tentative Methods of Compression Testing of Metallic Materials (E 9 – 25 T)	18	0	29
III. APPROVAL OF ADVANCEMENT TO STANDARD OF METHODS AS RECOMMENDED BY COMMITTEE D-2			
5. Tentative Method of Test for Distillation of Gasoline, Naphtha, Kerosine, and Similar Petroleum Products (D 86 – 26 T)	29	0	18
6. Tentative Method of Test for Distillation of Natural Gas Gasoline (D 216 – 25 T)	29	0	18
IV. FOR PUBLICATION AS INFORMATION			
7. Comparison of Foreign Practice on Standard Tension Test Specimens	25	0	22

This report has been submitted to letter ballot of the committee with the following result: Advisory Committee: 7 Affirmative, 0 negative, 0 not voting; total, 7. Standing Committees: 27 Affirmative, 0 negative, 13 not voting; total, 40.

Respectfully submitted on behalf of the committee,

J. A. CAPP,
Chairman.

R. E. HESS,
Ex-Officio Secretary.

EDITORIAL NOTE

The Tentative Method of Verification of Testing Machines by Means of an Elastic Calibration Bar, revised as recommended by the committee, was approved at the annual meeting and subsequently adopted by letter ballot of the Society on September 1, 1927, to be added to the present Standard Methods of Verification of Testing Machines. The methods as revised appear in the 1927 Book of A.S.T.M. Standards, Parts I and II. The Tentative Methods of Brinell Hardness Testing of Metallic Materials were approved at the annual meeting and subsequently adopted by letter ballot of the Society on September 1, 1927. The methods appear in the 1927 Book of A.S.T.M. Standards, Part I.

The proposed revisions of the Tentative Methods of Tension Testing of Metallic Materials; and of Compression Testing of Metallic Materials were accepted. The methods as revised appear on pages 1067 and 1081, respectively.

APPENDIX

FOREIGN PRACTICE WITH RESPECT TO STANDARD TENSION TEST SPECIMENS

Country and Body	Date of Report	Material and Purpose	Gage Length	Width of Reduced Section	Length of Reduced Section	Radius of Fillets
1. Great Britain:	5-10-26	Copper and Brass Sheets for Aircraft	4 in.	$1\frac{1}{4}$ in. (*f*)	....	....
Br. Eng. Std. Assn.		Aluminum and Aluminum Alloys	2 in. (*a*)	$\frac{3}{4}-1\frac{1}{8}$ in.	$2\frac{1}{2}$ in. (*m*)	$3\frac{1}{2}$ in. (*m*)
		Except for *t* less than 0.049 in	2 in. (*a*)	$\frac{1}{2}-\frac{7}{8}$ in.	$2\frac{1}{2}$ in. (*m*)	$3\frac{1}{2}$ in. (*m*)
		Steel Sheets for Aircraft	4 in.	$1\frac{1}{4}$ in. (*t*)	4 in. (*m*)	....
2. Switzerland (P):	5-3-26	Flat Wrought Metals				
Bur. des Normes	(*M-E*)	*t* less than 0.2 in	$11.3\sqrt{12t^2}$	$12t$	$GL+0.8$ in.	1.4 in.
		t 0.2 - 1.2 in	7.87 in.	$314t$	8.66 in.	1.4 in.
		t greater than 1.2 in	round specimen			
3. Germany (P):	6-17-26	Thin Brass Sheet *t* 0.04 in	$11.3\sqrt{A}$	0.60 in.	....	....
D. V. M.	(*M-E*)	Proposed Standard *t* 0.020 - 0.250 in.	$11.3\sqrt{A}$	$10-20t$	$12.5\sqrt{A}$	$1.5w$ (*m*)
4. Sweden:	6-7-26	*t* less than 0.16 in	$11.3\sqrt{A}$	0.4 - 0.8 in.	....	....
Statens Prov.	(*M-E*)	*t* 0.16 - 0.32 in	$25t+1w$	$5t$	$25t+2w$	....
		t 0.32 - 0.72 in	9.6 in.	$314\sqrt{t}$	11.2 in.	....
5. Denmark:	9-24-26	*t* up to 0.012 in	4.0 in.	0.80 in.	straight specimen	
D. D. S.	(*M-E*)	*t* 0.012 - 0.060 in	2.4 in.	0.80 in.	4.0 in.	0.4 in. (*m*)
		t 0.060 - 0.256 in	4.8 in.	0.80 in.	4.8 in.	0.6 in. (*m*)
6. Japan: J. E. S. C.	10-1-25 (*M-E*)	*t* under 0.350 in	7.87 in.	2.36 in. (*x*)	8.66 in.	....
7 Norway: N. I. S.	6-15-26	"No standard methods for testing thin sheet metals."				
8. Belgium: N. S. B.	3-16-26	"Government specifications under revision—no information available."				

ABBREVIATIONS:

m = minimum; x = maximum
t = thickness
w = width of reduced section
A = minimum area of cross section
GL = gage length

p = taper permitted in reduced length
p = "usual practice," no standard
f = for narrower strip, use full width
a = indefinite in report
$M-E$ = values converted from metric system

REPORT OF COMMITTEE E-4
ON
METALLOGRAPHY

Committee E-4 held a meeting at Atlantic City on June 23, 1926, and a second meeting in Philadelphia in conjunction with many of the other committees of the Society, on March 17, 1927.

Sub-Committee I on Selection and Preparation of Samples, reports the resignation of Mr. William Campbell as chairman on account of ill health, and Mr. G. F. Comstock has been appointed to take his place. Mr. Comstock presents a brief report, appended hereto, comprising an abstract of a discussion of Mr. Groesbeck's paper on "Solutions for Carbides, etc., in Alloy Steels," appended to the report of Sub-Committee I of Committee E-4 in 1926.[1]

The sub-committee presents the following note on etching nickel silver:

NOTE ON ETCHING NICKEL SILVER

Boiling ferric-ammonium-sulfate solution is recommended by Mr. J. T. Kemp of the American Brass Co. as an etching reagent for nickel silvers. The results are illustrated by two photomicrographs, each at a magnification of 100 diameters. Figure 1 shows the structure of a hot-rolled rod containing 73.83 per cent of copper, 5.24 per cent of zinc, and 20.16 per cent of nickel, annealed, and etched by boiling the polished specimen with a small crystal of the salt in a watch glass. Figure 2 shows the structure of an 0.24-in. sheet, also annealed, containing 64.52 per cent of copper, 17.41 per cent of zinc, and 17.93 per cent of nickel. This specimen was etched by Mr. L. P. Webert in 100 cc. of boiling 5-per-cent ferric ammonium sulfate for about four minutes.

Sub-Committee II on Nomenclature and Definitions presents the following definition of the term "metallography," which definition was submitted last year for publication as tentative,[2] and since revised by Committee E-4 in the light of criticisms received from Committee E-8 on Nomenclature and Definitions. The definition is now recommended for adoption as standard as follows:

"*Metallography.*—That branch of science which relates to the constitution and structure, and their relation to the properties, of metals and alloys."

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 26, Part I, p. 569 (1926).

[2] *Proceedings*, Am. Soc. Testing Mats., Vol. 26, Part I, p. 1092 (1926); also 1926 Book of A.S.T.M. Tentative Standards, p. 993.

This definition is in the form of other standard definitions and is consistent with the present standard definition of the term "metal."

Sub-Committee III on Thermal Analysis recommends that the present Tentative Recommended Practice for Thermal Analysis of Steel (E 14 - 25 T) be continued as tentative. Mr. W. E. Ruder, the chairman of the sub-committee, has resigned and until a new chairman is appointed the Recommended Practice is being continued as tentative since, in view of some criticism of the present tentative recommended practice, it may need to be revised before it is advanced to standard.

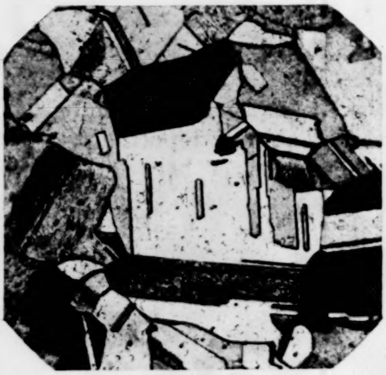

FIG. 1.—Hot-Rolled Copper-Zinc-Nickel Alloy. Annealed. Etched with Boiling Ferric-Ammonium-Sulfate Solution (×100).

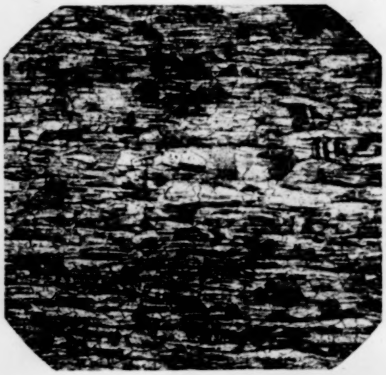

FIG. 2.—Copper-Zinc-Nickel Alloy in Sheet Form. Annealed. Etched with Boiling Ferric-Ammonium-Sulfate Solution (×100).

Sub-Committees IV on Photography and V on Micro-Hardness, of both of which Mr. H. S. Rawdon is chairman, have presented no report during the year. On the recommendation of Mr. Rawdon Sub-Committee V has been discharged, as its work on micro-hardness has been completed.

The Tentative Recommended Practice for the Care of the Eyes when Using a Metallographic Microscope (E 2 - 26 T)[1] is recommended for advancement to standard, to be combined with the present Recommended Practice for Photography as Applied to Metallography, in Standard Rules E 2 - 24.

The tentative revisions of the Standard Methods of Metallographic Testing of Non-Ferrous Metals and Alloys (E 5 - 24)[2] appearing in the Proceedings of the Society as submitted by Committee E-4 in 1926[1] are recommended for adoption as standard with the following important addition to the list of references:

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 26, Part I, p. 1098 (1926); also 1926 Book of A.S.T.M. Tentative Standards, p. 1001.

[2] 1924 Book of A.S.T.M. Standards.

(17) Vilella, J. R., "Delving into Metal Structures, Part III," *Iron Age*, Vol. 117, pp. 903–907, 1926.

This is the third of a series of articles presenting new etching reagents. J. R. Vilella has modified an HF-HNO_3 reagent by using glycerin as a solvent. The development of the microstructure of aluminum alloys by this etch is discussed. The author states that different constituents are readily identified and has presented several micrographs to illustrate the etching effects. A general discussion of etching is also included.

(Abstractor's Note: The etching information presented is of value but the etching reagent has limitations and is not to be relied upon unless all other conditions are standardized.)

As mentioned above, the Tentative Recommended Practice (E 14 – 25 T) is being recommended to be continued as tentative. The Tentative Recommended Practice for Radiographic Testing of Metal Castings (E 15 – 26 T) is also recommended to be continued as tentative.

The committee wishes to emphasize its recommendation made in its last report, which recommendation was approved by the whole committee, that the Society print its photomicrographs on a better grade of paper and use a finer screen, which procedure would enhance greatly the value of the reports and papers on metallography. Such a course is in line with the practice of other scientific societies.

The recommendations appearing in this report have been submitted to letter ballot of the committee with the following results:

Items	Affirmative	Negative	Not Voting
1. Advancement to standard of Tentative Definition of the Term Metallography (E 7 – 26 T)	36	0	0
2. Advancement to standard of Tentative Recommended Practice for the Care of the Eyes When Using a Metallographic Miscroscope (E 2 – 26 T)	36	0	0
3. Advancement to standard of Revisions of Standard Methods of Metallographic Testing of Non-Ferrous Metals and Alloys (E 5 – 24)	35	0	1

This report has been submitted to letter ballot of the committee, which consists of 49 members, of whom 36 have voted affirmatively, none negatively, and 13 have refrained from voting.

Respectfully submitted on behalf of the committee,

H. C. BOYNTON,
Chairman.

G. F. COMSTOCK,
Secretary.

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 26, Part I, p. 1142 (1926).

EDITORIAL NOTE

The tentative revisions of the Standard Methods of Metallographic Testing of Non-Ferrous Metals and Alloys, revised as recommended by the committee, were approved at the annual meeting and subsequently adopted by letter ballot of the Society on September 1, 1927. The methods as revised appear in the 1927 Book of A.S.T.M. Standards, Part I.

The Tentative Recommended Practice for the Care of the Eyes when Using a Metallographic Microscope was approved at the annual meeting and subsequently adopted by letter ballot of the Society on September 1, 1927, to be added to the Standard Rules Governing the Preparation of Micrographs of Metals and Alloys. The rules as revised appear in the 1927 Book of A.S.T.M. Standards, Part I.

The Tentative Definition of the Term Metallography was approved at the annual meeting and subsequently adopted by letter ballot of the Society on September 1, 1927, to be added to the Standard Definitions of Terms Relating to Metallography. The definitions as revised appear in the 1927 Book of A.S.T.M. Standards, Part I.

APPENDIX

DISCUSSION BY J. B. JOHNSON ON ETCHING OF STEELS WITH VARIOUS REAGENTS

Abstracted by George F. Comstock[1]

A discussion of Mr. Groesbeck's paper on "Etching Reagents for Carbides, etc., in Alloy Ateels" published as a supplement to the report of Committee E-4 in 1926, was received by the committee from Mr. J. B. Johnson of McCook Field, Dayton, Ohio. This discussion was in the form of a report of work done by Messrs. F. T. Sisco and J. L. Hester in an effort to check Mr. Groesbeck's results, and was profusely illustrated by photomicrographs.

The following steels were used in this work, mostly in both the hardened and annealed states, and the examinations were made chiefly at 500 diameters:

Carbon steel, 1.3 per cent of carbon; chromium steels, 1.2 per cent of carbon, 1.3 per cent of chromium; also 2 per cent of carbon, 13 per cent of chromium; and 1.2 per cent of carbon, 1.2 per cent of silicon, 18 per cent of chromium; high-speed steel, 3 to 4 per cent of chromium, 1 per cent of vanadium, 18 to 19 per cent of tungsten.

The specimens were mounted in solder when polished and etched.

Sisco and Hester summarized their results on etching as follows:

1. *Alcoholic Nitric Acid.*—Etches evenly and rapidly; does not differentiate between the carbides of varying compositions; distinguishes between structural components present, for example, between austenite and martensite. The time of etching varies erratically.

2. *Murakami's Reagent.*—Etches erratically and unevenly; differentiates sharply between the carbides in hardened high-speed steel and in hardened chrome steel; does not act on the carbides in annealed high-speed steel.

3. *Alkaline Sodium Picrate.*—Etches erratically and unevenly; does not distinguish between carbides of varying compositions; does not give satisfactory results in identifying structural components.

4. *Ferric Chloride and Nitric Acid.*—Etches rapidly and evenly; does not identify the carbides in carbon, chromium, and high-speed steels except in the case of hardened high-speed steel, which might be identified by this reagent; differentiates between the various structural constituents present. This reagent should be studied further.

5. *Alkaline Potassium Permanganate.*—Etches erratically; stains the specimen unevenly; does not identify carbides of various compositions. The carbides are attacked but could not be differentiated. The reagent is unreliable.

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[1] Chairman, Sub-Committee I, of Committee E-4, on Selection and Preparation of Samples.

6. *Aqua Regia in Glycerin.*—Etches erratically; does not attack carbides. The reagent has a characteristic action upon the matrix of hardened high-speed steel which differentiates it from the matrix of hardened austenitic chromium steel.

7. *Sodium Oxalate, Electrolytic.*—Etches erratically; dissolves the carbides leaving pits. This etch is unreliable.

8. *Sodium Carbonate, Electrolytic.*—Etches high-chromium steels rapidly and evenly; high-speed steel and carbon steel slowly and erratically. It may be possible to differentiate between the carbides of chromium steel, high-speed steel, and carbon steel by this reagent. It may be possible to identify chromium carbides of various compositions by it also. Further work on it is advisable.

9. *Sodium Hydroxide, 10-per-cent, Electrolytic.*—Is unreliable in general. It may be possible to differentiate iron carbide from chromium carbides and the carbides in high-speed steel by this etch, but it does not afford a positive means of identifying any of the other carbides.

10. *Sodium Hydroxide, 1-per-cent, Electrolytic.*—Etches satisfactorily but the time of etching varies greatly; differentiates sharply between the chromium carbides present in the 2-per-cent carbon, 13-per-cent chromium and in the 1.2-per-cent carbon, 1.2-per-cent silicon and 18-per-cent chromium steels; distinguishes between the carbides in chromium and in high-speed steels. Iron carbide and the carbides in high-speed steel respond similarly to the etch but probably could be identified by their difference in form.

The full report of the detailed observations, with photomicrographs, is on file with the secretary of Committee E-4 and may be consulted upon application to him.

It would seem that this subject is worthy of further discussion, and for this reason this abstract is submitted for publication.

DISCUSSION

MR. E. C. GROESBECK[1] (*presented in written form*).—In 1926, the writer presented through Committee E-4 a paper on etching reagents for carbides in alloy steels.[2] A discussion of this paper was received from Mr. J. B. Johnson, comprising a report of work done by Messrs. F. T. Sisco and J. L. Hester in an effort to check the writer's results.[3] The writer wishes to present a few comments on that report.

Mr. Groesbeck.

The use of solder for mounting the specimens mentioned in that report was an unfortunate procedure, especially in the electrolytic etching tests. The writer, appreciating the fundamental nature of the investigation, avoided the use of any metallic mounting wherein the etching results might be vitiated through the presence of reaction products, but followed what seemed to be a simple and sure method of using unmounted specimens of sufficient size as would afford convenient handling and also a large enough microsection (up to about 1½ sq. in.) that would give unquestioned etching results. Another reason for using unmounted specimens was that it was believed the corroding action of the etching reagent would be more readily directed to the carbide particles, as the essential value of the etching method was to have the different carbides, etc., attacked and at the same time have the matrix, or solid solution, remain unattacked. The use of the solder appears to account for the erratic and uneven etching results reported by Sisco and Hester, especially in view of the fact that tin is attacked by an aqueous solution of an alkali; on the other hand, the reported even and rapid etching results with a nitric acid reagent might possibly be ascribed to the ready solubility of lead nitrate in water.

The writer found the time factor to be an important consideration, as by controlling this factor it was possible in many cases to distinguish one type of carbide from another by the rate of the response made by the carbide particles to the corrosive action of the etching reagent, although the various types of carbides were attacked, or "eaten out," in apparently the same manner. The following cases,

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[1] Division of Metallurgy, U. S. Bureau of Standards, Washington, D. C.

[2] E. C. Groesbeck, "Solutions for Carbides, etc., in Alloy Steels," Appendix to Report of Committee E-4 on Metallography, *Proceedings*, Am. Soc. Testing Mats., Vol. 26, Part I, p. 569 (1926).

[3] For an abstract of the discussion, see p. 601.—ED.

Mr. Groesbeck. taken from the writer's experimental work, may be cited as an illustration of this.

1. *Simple Immersion:* A boiling hot alkaline sodium picrate solution ("Kourbatoff's reagent").—The carbide particles in high-speed steel are completely attacked in about 1½ minutes while the cementite particles in a plain carbon steel required 5 to 10 minutes. The identity of these two types of carbide particles could be checked up by etching in a 10-per-cent sodium hydroxide solution at room temperature where the high-speed steel carbide particles would be attacked within 10 minutes while the cementite particles would remain unattacked after 30 minutes' immersion.

2. *Electrolytic Etching:* 10-per-cent sodium hydroxide solution.—The high-speed steel carbide particles were attacked in 1 minute while the cementite particles required about 30 minutes' exposure and a little stronger current. The chromium carbide particles of chromium steels were attacked in 1 to 2 minutes, and therefore no clear distinction between these and the high-speed steel carbide particles, should both these types of carbides be present in the same microsection, would be practicable with this reagent and method of etching. However, by etching electrolytically in a dilute ammonium hydroxide solution (containing 3 per cent of NH_3 by weight) the chromium carbide was fully attacked within ½ minute while the high-speed steel carbide remained unattacked after 2 minutes.

The following are a few comments offered on the various items of Sisco and Hester's report:

Items 1, 4 and 6.—The writer, having determined early in his work[1] that reagents of an acidic nature do not attack the different types of carbides in various alloy steels, directed his attention to solutions of an alkaline nature, since these were found to attack more or less completely the various types of carbides. Acidic reagents are satisfactory for developing the structure of the matrix, but are of no value where differentiation among the types of carbides is desired and preferably with no accompanying attack of the matrix.

Item 2.—Daeves (**1**)[2] and Loskiewicz (**2**) appear to have had satisfactory results with this reagent, or else would in all likelihood not have recommended its use or would probably have commented on any erratic and uneven etching behavior persistently shown by this reagent. Furthermore, Honda and Murakami (**3**) found this solution satisfactory for darkening the carbide particles in high-speed steel, reporting an etching period of 10 to 15 seconds at room temperature as being sufficient. The writer found in his tests that 1 minute's etching of both hardened and annealed high-speed steel specimens at either room or boiling hot temperature was amply sufficient. Hence

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[1] Bureau of Standards *Scientific Paper No. 518*, Metallographic Etching Reagents, III: For Alloy Steels (1925).

[2] The boldface numbers in parentheses refer to the papers given in the list of references appended hereto.

Mr. Groesbeck.

the statement that this reagent "does not act on the carbides in annealed high-speed steels" evidently is not in agreement with the experience of others.

It may be mentioned here that Grossman and Bain (4) have reported that under average hardening conditions somewhat less than one-half of the carbide in high-speed steel (representing about 30 per cent by weight of the steel and consisting of a complex carbide, which in annealed steel contains approximately all of the carbon, tungsten and vanadium present in the steel, together with about one-half of the chromium) is dissolved in the matrix when the steel is heated for quenching.

The statement "differentiates sharply between the carbides in hardened high-speed steel and in hardened chrome steel" needs amplification, as to what this differentiation is. The writer found that this reagent readily attacks the free carbide particles in hardened chromium steels containing sufficient carbon and chromium content to give free carbide particles; on the other hand he did not find any free carbide present in two hardened steels, containing 0.8 per cent of carbon and 4.3 per cent of chromium, and 0.75 per cent of carbon and 6.0 per cent of chromium.

Item 3.—The unsatisfactory results reported by Sisco and Hester are evidently due to the use of solder, for it is common knowledge that this reagent has been used by many with entire satisfaction for identifying cementite in carbon steels. In the writer's tests, the carbide particles in high-speed steel were readily attacked (about 1½ minutes) and the cementite in carbon steels somewhat more slowly (5 to 10 minutes), while chromium carbide in chromium steels (also tungsten carbide in tungsten steels and vanadium carbide in steels with high vanadium and carbon content) remained unattacked after 15 to 20 minutes' immersion. Guillet (5) and Murakami (6) have reported that chromium carbide in chromium steels is not attacked ("darkened") by this reagent.

Items 4 and 6.—Since the statement is made that these reagents do not attack the carbides, the only possible value of either or both of these reagents seems to lie solely in the development of the structure of the matrix. Similar results probably could be obtained with some other and suitably selected acidic reagent.

Item 5.—Inasmuch as this solution is of a strongly oxidizing nature, the tarnishing of the polished surface of the specimen is liable to occur. This difficulty is easily avoided by quickly transferring the specimen from the etching dish to a vessel, placed close by and containing water at room temperature, and rinsing it. A precaution-

Mr. Groesbeck. ary note regarding this detail of etching procedure was, through an oversight, not inserted in the writer's paper presented in 1926. The writer repeatedly obtained very clean and satisfactory results with this solution, which should be used hot. As already referred to in Section II (*a*) of the writer's paper, this solution does not distinguish between the various types of carbides, yet it may be used, as well as alkaline potassium ferricyanide solution, for confirming the presence of any certain type of carbide assumed to be present.

Item 7.—The writer's tests showed that by using a potassium oxalate solution of normal strength the cementite particles in a high-carbon steel were not attacked during a 10-minute etching, while the chromium carbide particles in chromium steels were, with the same strength of current, attacked within 2 minutes. The matrix was, however, corroded in a quite general, though not deep, manner in many cases, evidently due to the formation of oxalic acid in the reaction.

Item 9.—The judgment passed that this is "unreliable in general" is not in accordance with the writer's experience. Furthermore, Oertel and Pakulla (7) employed this solution in etching, electrolytically, high-speed cutting tools made from alloys similar to stellite, and gave in their paper several very satisfactory micrographs.

It is not clear what is meant by "any of the other carbides" referred to at the end of the paragraph, for it was stated that only three types of carbides were tried in Sisco and Hester's tests. Chromium carbides may be distinguished from the carbides in high-speed steel by etching electrolytically in a 10-per-cent potassium acetate solution; the former is attacked within 1 minute while the latter (and also iron carbide and iron tungstide) remain unattacked, using the same strength of current, after at least 2 minutes. (See Section V (*b*), Paragraph 1 of the writer's paper). Or, etching by simple immersion in sodium hydroxide solution and hydrogen peroxide mixture ("Yatsevitch's reagent") can be used for distinguishing chromium carbides from carbides in high-speed steel (See Section V (*a*), Paragraph 1).

Item 10.—The time of etching factor is an important consideration here. Chromium carbides are readily attacked while the carbides in high-speed steel are relatively very slowly attacked. Cementite is slowly attacked but more rapidly so than the carbides in high-speed steel. This etching procedure has been recommended only for distinguishing chromium carbides from the other two types of carbide, because of the differentiation made possible by the relative speeds of attack.

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(4) M. A. Grossman and E. C. Bain, "On the Nature of High-Speed Steel," *Journal*, Iron and Steel Inst., Vol. 110, p. 249 (1924).

(5) L. Guillet, "Étude Industrielle des Alliages Metalliques," Dunod et Pinot, Paris, 1906.

(6) T. Murakami, "On the Structure of Iron-Chromium-Carbon Alloys," *Science Reports*, Tôhoku Imperial Univ., Vol. 1, p. 217 (1918); also *Journal*, Iron and Steel Inst., Vol. 100, p. 447 (1919).

(7) W. Oertel and E. Pakulla, "Beitrag zur Frage der Kobalt-Chröm-Wolfram-(Molybdän-) Legiergungen," *Stahl und Eisen*, Vol. 44, p. 1717 (1924).

REPORT OF COMMITTEE E-5

ON

STANDING COMMITTEES

One of the principal functions of Committee E-5 on Standing Committees is the study of the Regulations Governing Standing Committees of the Society, which fundamentally control our committee procedure and the methods of formulating standards. The responsibility for these Regulations is vested jointly in the Executive Committee of the Society and Committee E-5.

Since its report[1] to the Society in 1922, there have until this year been no questions affecting committee procedure of sufficient importance and urgency to require the consideration of the committee. Within the past year, however, certain proposals for modifications of committee procedure have come from various sources and other questions have been referred to the committee by the Executive Committee for study. The committee accordingly met at Society headquarters on November 12, 1926, and discussed very fully a number of proposed modifications of the Regulations Governing Standing Committees. The decisions reached at the meeting, as recorded in this report, were separately ratified by a letter ballot vote of the entire committee and were reported to the Executive Committee. With two exceptions, noted herein, these decisions were formally approved by the Executive Committee; whereupon the detailed modifications of the Regulations Governing Standing Committees required by these decisions were drafted and submitted to letter ballot vote of Committee E-5, which has resulted in their adoption by a vote of 40 affirmative, none negative and one not voting. The revisions are given in detail in this report and the Regulations in their revised form are appended to the report.[2] By direction of the Executive Committee the revised Regulations are effective July 1, 1927.

In the following paragraphs are discussed briefly the more important modifications that have been made, with certain explanations of considerations that have led to their adoption. Mention is also made of certain questions that are still under consideration.

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 22, Part I, p. 534 (1922).

[2] The Regulations Governing Standing Committees, in their revised form, appear in the 1927 A.S.T.M. Year Book, p. 317.

Classification of Committee Membership:

It has been in mind, ever since the participation of the Society in the organization of the American Engineering Standards Committee, to classify the membership of the standing committees of the Society into "producers," "consumers" and "general interests" instead of producers and non-producers as at present. In classifying the personnel of so-called sectional committees under A.E.S.C. procedure, it was found to be advantageous to subdivide the non-producer group into consumer and general interest groups, and the following definitions of the three groups were adopted:

Producers.—Those directly concerned in the production and sale of the commodity involved;

Consumers.—Those that use the commodity involved but are not directly concerned with its production and sale;

General Interests.—Independent engineers, educators and persons who are neither consumers nor producers as defined above.

The experience gained in A.E.S.C. sectional committee work has fully justified this method of classification. It is desirable to distinguish in so far as possible between actual consumers of commodities within the province of the committee and those in the general interest group who have heretofore been classified with the consumers under the heading "non-producers," but who are not actually consumers. A further advantage of this method of classification is that it facilitates the approval of standing committees of the Society as sectional committees under A.E.S.C. procedure, in which the proposed method of classification is required.

This modification of the Regulations involves principally Section 2 and in an incidental way Sections 3, 4 and 9.

Attention is particularly directed to the fact that no modification is made in the present requirements for numeric balance between representatives of producing and non-producing interests (the latter now to be divided into consumers and general interests), nor in the provision defining the condition under which a nominally unattached expert shall be classed as a producer.

Votes of Committees on Standards and Reports:

The Regulations at present prescribe (Section 15) that action of committees relating to standards at meetings and on subsequent letter ballot shall be determined by majority vote of those voting and (Section 10) that committee reports require for their adoption a majority vote of those voting on letter ballot. It is believed that more than a mere majority vote of those voting in a committee should be required for the submission of recommendations affecting standards and the presentation of annual reports. It was accordingly decided that a two-thirds vote should be required in these cases, which, incidentally, brings this procedure into line with the requirements for votes by the Society itself at annual meeting and in letter ballot.

These modifications of the Regulations apply to Section 10 (renumbered 17) and Section 15 (renumbered 14). In the former section a further minor modification has been made in the method of reporting the results of letter ballots of committees, making a distinction between members who have not returned their ballots and those who have returned them but have marked them "not voting."

Inclusion in Committee Reports of Data Respecting New Standards and Revision of Existing Standards:

For several years the Executive Committee has, prior to each annual meeting, called the attention of the standing committees to the importance of including in their annual reports the essential facts regarding the origin of all proposed new standards and the reason for proposing amendments in existing standards and tentative standards. An examination of committee reports over a number of years has revealed a rather disturbing lack of information regarding the origin and history of many of the Society's standards and the reasons for recommending revisions in standards from time to time. Our committees have frequently submitted entirely new specifications with little or no statement of the circumstances that led the committee to consider it desirable or necessary that these specifications be prepared and with insufficient data regarding the basis of the specifications. Similarly, committees have proposed revisions of standards with no indication of why the revisions are desirable. It is believed that information of this kind in concise form should be required to appear in annual committee reports.

Along somewhat similar lines and as a result of the activities of Committee E-1 on Methods of Testing in the review of our test methods, it is desirable that in offering methods of test for adoption by the Society, the standing committees shall submit the principal data upon which the proposed methods of test have been based or which may have led to proposed revisions in existing methods. These basic data are usually in the form of tests and are sometimes though not always made a part of the committee's report to the Society. Such data need not be published *in extenso* but may be filed with Committee E-1; or reference to available publications is acceptable.

A careful observance of these provisions will add much both to the current and historical value of our committee reports. The revisions relating thereto appear in Section 10 (renumbered 17).

Continuation of Tentative Standards:

Announcement was made in the report of the Executive Committee to the Society in 1926 that standing committees should state either to the Executive Committee or to the Society in their annual reports their reasons for continuing a tentative standard or a proposed revision of an existing standard in a tentative status for more than three years without revision or without recommendation for advancement to standard. It seemed desirable to Committee E-5 that this requirement be suitably embodied in the Regulations Governing Standing Committees and this has been done in Section 10 (renumbered 17).

Rulings Respecting Standards Involving Patents:

Section 18 of the present Regulations consists of a quotation of Article VI, Section 2 of the By-laws, as follows:

> "Reports, resolutions and recommendations pertaining to or involving the use, or proposed use, in a standard or tentative standard, of any device or process which forms the subject matter of any existing patent, shall first be submitted to the Executive Committee, and shall be submitted to the Society only with the approval of the Executive Committee."

The Executive Committee has adopted certain policies for the handling of cases involving patents that have in recent years been brought to it under the provisions of this requirement.[1] These statements of policy were referred to Committee E-5 with the suggestion that it might be desirable to include them in some appropriate way in the Regulations Governing Standing Committees. Committee E-5 concluded that these statements should be printed in connection with Section 18 (renumbered 16) and they now appear in the revised Regulations.

Miscellaneous Modifications:

Several other modifications have been made. In Section 7 it has been required that the results of election of officers be formally announced in committee reports. In Section 16 (renumbered 18) a slight modification has been made in order to comply with the policy of distributing preprints of committee reports now in effect. An interpretation of a provision in Section 17 (renumbered 15) relating to the adoption of amendments of existing standards is given as a footnote.

Finally, the provision has been added (Section 5) that minutes of standing committee meetings shall be kept and copies regularly filed with the Secretary-Treasurer of the Society.

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[1] For a more detailed statement of this matter, reference should be made to the 1927 report of the Executive Committee, see p. 86.—ED.

Questions Still Under Consideration:

Three matters affecting committee procedure are still under consideration by the committee which may lead to further modifications of the Regulations Governing Standing Committees.

The first is a suggestion that it might be desirable to report letter ballot votes of the members of standing committees in all matters affecting standards in such a way as to indicate the number of producers, consumers and general interests that have, respectively, cast affirmative or negative votes or have asked to be recorded as "not voting." The discussion of this suggestion revealed a considerable difference of opinion. Some felt that the suggestion was a good one and that the Society should know how these three groups have recorded themselves with respect to a particular recommendation. Others questioned whether anything really worth while would be gained by imposing this requirement upon the committee, pointing out that it would require considerable clerical work on the part of committee officers. (With respect to each item in a ballot it would be necessary, theoretically, to record the vote in nine sub-divisions.) It was finally decided to refer the matter to a sub-committee for further study.

The second point relates to the procedure in a sub-committee charged by the parent standing committee with the development of complete standards. To one who has studied the growth and development of the procedure by which the Society formulates a standard, it will be evident that to an increasing degree the actual work of formulating standards is being done by sub-committees. While in a sense this has been true for a number of years, the increased size of some of our larger committees has served to accentuate the responsibility that is placed in this way upon the sub-committees. To the extent that this is so, the Society is becoming more and more dependent in the development of acceptable standards upon the adequacy of the personnel of these sub-committees, the care with which their work is done and the rigidness of their procedure. Under our present Regulations (see Section 9) the sub-committees have no direct relation to the Society and report only through their parent committees. It has heretofore not been considered necessary to prescribe procedure for sub-committees, this having been left to each standing committee to decide for itself.

In view of these developments, consideration was given at the meeting of Committee E-5 to a proposal that a two-thirds vote of the entire membership of a sub-committee should be required for adoption by the sub-committee of a proposed new standard or proposed amendment of an existing standard, prior to its submission to the parent standing committee. The discussion developed differences of opinion; but a modification of the proposal by which the proposed two-thirds vote of a sub-committee should be required, not prior to *submission to* but prior to *adoption by* the standing committee, was approved at the meeting and referred to a letter ballot vote, which resulted in 30 affirmative and 8 negative votes. The proposal was submitted to the Executive Committee who referred it back to Committee E-5 for further consideration in view of its fundamental importance.

The third matter relates to difficulties that have occasionally developed at Annual Meetings when committees make recommendations affecting standards that have been determined upon at committee meetings held during the Annual Meeting and have therefore not been submitted to the required letter ballot vote of the committee members. A tendency has been noticed in recent years for important actions of this kind to be taken at such committee meetings, and the attention of the standing committees has for several years been called to the provisions of the Regulations and to the undesirability of such "eleventh hour" actions, stressing the importance of making every effort to have all recommendations affecting standards completely worked out at the spring committee meetings so that only typographical modifications of preprinted reports will in general be necessary. Committee E-5 considered a proposal that final approval by letter ballot of the Society of any revisions of the recommendations in a committee's report affecting standards as may be offered on the floor of the Annual Meeting, shall be contingent upon subsequent approval of such proposed modifications by letter ballot vote of the standing committee concerned. This proposal was subsequently approved by letter ballot vote of the committee, 35 affirmative, 3 negative, but after study of the proposal, the Executive Committee requested Committee E-5 to give it further consideration.

These three subjects are now being studied by a sub-committee consisting of J. A. Capp, chairman, Julius Adler, Cloyd M. Chapman, J. H. Gibboney and Allen Rogers.

REVISIONS IN THE REGULATIONS GOVERNING STANDING COMMITTEES[1]

(Approved Jointly by the Executive Committee and Committee E-5 on Standing Committees. Effective July 1, 1927.)

The revisions that have been made in the Regulations Governing Standing Committees are given in detail below. Words in italics have been inserted; words in brackets have been deleted. A slight rearrangement of the order of certain sections has been found desirable.

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[1] 1926 A.S.T.M. Year Book, p. 300.

2. Appointments ***and Classifications.***—Appointments on standing committees shall be made by the Executive Committee subject to the following provisions:

(*a*) On committees dealing with subjects having a commercial bearing, *the members of the committee shall be classified into "producers," "consumers," and "general interests," defined as follows:*

> *Producers.—Those directly concerned in the production and sale of the commodity involved;*
>
> *Consumers.—Those that use the commodity involved but are not directly concerned with its production and sale;*
>
> *General Interests.—Independent engineers, educators and persons who are neither consumers nor producers as defined above.*

On such committees either an equal numeric balance shall be maintained between the producers on the one hand, and the consumers and general interests, jointly, on the other hand; or the consumers and general interests may be allowed to predominate by majority vote of the producers. [either an equal numeric balance shall be maintained between the representatives of producing and non-producing interests; or the latter may be allowed to predominate by majority vote of the former.]

(*b*) The classification of the members of a committee into producers, *consumers, and general interests* [and non-producers] shall be left to each committee, subject to the following provisions, and with the understanding that a member dissatisfied with this classification has the right of appeal to the Executive Committee:

(1) A member who stands in the relation of producer to any product within the province of the committee shall be classed as a producer, although at the request of the officers of the committee concerned, attention shall be called to the status of such members in a footnote worded as follows:

> These members of Committee ......, classed as Producers, stand in the relation of Producers to certain products, and in that of *Consumers* (*or General Interests*) [Non-Producers] to other products within the province of the committee.

(Remainder of section unchanged.)

3. Preliminary Organization.—The President of the Society will appoint the chairman pro tem. of a new committee from *among* the *consumers or general interests.* [representatives of the non-producing interests.] (Remainder of section unchanged.)

4. Permanent Organization.—At the first meeting of a committee a permanent organization shall be effected by the election of a permanent chairman from among the *consumers or general interests,* [representatives of non-producing interests,] and such other officers [and sub-committees] as the committee may desire, *and the creation of such sub-committees as may be desired.* The duties and powers assigned to these officers and sub-committees, and the details of management and administration in general, shall be at the discretion of each committee, subject to the limitations of these Regulations.

5. Meetings.—The meetings of standing committees and sub-committees shall be open only to their own members and to such visitors whose proposed invitation has been approved by the chairman.

Minutes of meetings of standing committees shall be kept and copies thereof shall regularly be sent to the Secretary-Treasurer of the Society.

7. Election of Officers.—Every standing committee shall hold an election of officers at or before the annual meeting of the Society occurring in the even years. *The result of such election shall be included in the report of the committee for that year.* The term of office of every officer shall be two years and officers shall be eligible for re-election.

9. Sub-Committees.—Sub-committees shall have no standing in the Society except through their parent committees. Sub-committees on proposed complete standard specifications for materials shall consist of not fewer than six members and at least one-half of the membership shall be composed of *consumers and general interests.* [non-producers.] Departures from this requirement for exceptional reasons may be authorized by the Executive Committee.

IV. [III.] REPORTS OF STANDING COMMITTEES.

17. **[10.] Reports.**—The reports of standing committees shall be presented at the annual meetings. The report of every sub-committee shall be made to the parent committee and not to the Society direct. If such a report is embodied wholly or in part in the report of the parent committee to the Society, the latter shall make definite references to such features in its own report and recommendations, if any, based thereon.

Standing committees shall include in their annual reports, in concise form, a statement of the essential facts regarding the origin of all proposed new standards and the reasons for proposing amendments in existing standards and tentative standards. Appropriate data respecting new methods of test or proposed modifications of existing methods of test shall be included in such annual reports or filed with Committee E-1 on Methods of Testing, as may seem preferable. Reference to available publications shall be accepted as appropriate data.

Standing committees shall include in their annual reports, or in a formal statement to the Executive Committee of the Society in case there is no report for a given year, their reasons for continuing a tentative standard or tentative revision of an existing standard in the tentative status for more than three years without revision or without recommendation for advancement to standard.

The results of letter ballot votes of the committee on actions affecting standards shall be announced in the report of the committee (see Section 14).

The report of a standing committee, before its presentation at the annual meeting, shall first have been submitted to letter ballot of the committee and shall have received the approval of *at least two-thirds* [the majority] of those voting.

A statement of the following form shall appear at the close of every committee report:

> This report has been submitted to letter ballot of the committee which consists of ...... members; ...... *members returned their ballots,* of whom ...... have voted affirmatively, ... negatively, and ...... have *marked their ballots "not voting."* [refrained from voting.]

Dissenting members shall have the right to present minority reports individually or jointly.

Renumber Sub-Division "IV. Standards and Recommended Practice" as Sub-Division III.

Renumber Sections 11 to 14, inclusive, as 10 to 13, inclusive.

14. [15.] **Preparation of Standards.**—Proposed new standards or proposed amendments of existing standards shall originate in the particular committee within whose province such standards properly belong. No action affecting standards shall be taken by any standing committee except at meetings called for that purpose. Action at such meetings shall be subject to *a two-thirds* [majority] vote of those voting, and subsequently to *a two-thirds* [majority] vote of those voting on letter ballot of the entire committee. (Remainder of section unchanged.)

18. [16.] **Advance Distribution of *Reports* [Standards].**—The annual reports of the standing committees shall be transmitted to the Secretary-Treasurer of the Society as early in the calendar year as possible and not less than eight weeks in advance of the date of the annual meeting. Preprints of these reports shall be mailed by the Secretary-Treasurer to every member of the Society *who has signified his desire to receive such reports,* at the earliest possible subsequent date and not less than four weeks before the annual meeting, so that members may come to the meeting prepared to discuss such reports and that members not intending to be present at the meeting may contribute discussions by letter.

Renumber Section 17 as Section 15. Add the following footnote at the end of the third paragraph of this section:

Interpretation.—The Executive Committee and Committee E-5 on Standing Committees have ruled that proposed revisions of amendments that have previously been accepted for publication as tentative must be germane to the original amendment in order to come under this provision. Revisions that are not germane to the original amendments shall be considered as new amendments.

Renumber Section 18 as Section 16. Add the following to this section:

Rulings.—The Executive Committee has adopted the following policies as applicable to standards involving patents:

Applying to the specifying of patented apparatus in A.S.T.M. Standards:

Where a standing committee desires to include in a standard of the Society the use of a patented instrument, appliance or machine for testing, for which the committee has written certain specifications, and where this instrument, appliance or machine is the only one specified in the standard, the Executive Committee will approve its inclusion in the standard provided the owner of the patent will execute a satisfactory agreement with the Society to license any reputable manufacturer approved by the Executive Committee to manufacture such instruments, appliances or machines for testing in accordance with the specifications of the Society.

Where the patented instrument, appliance or machine concerned is one of several alternative instruments that may be used in applying the standard of the Society, the other instruments not being patented, the Executive Committee will permit reference to such patented instrument without requiring the execution of an agreement such as above outlined, in the belief that the interests of the user of the standard are fully protected against an undesirable patent monopoly in that *he can use other unpatented instruments in accordance with the provisions of the standard.*

Applying to standards involving patented materials or patented processes: The Executive Committee will consider upon their respective merits any proposals from the standing committees of the Society that specifications be prepared involving patented materials or patented processes. If such specifications are adopted by the Society, the Society does not undertake to insure any one utilizing such specifications against liability for infringement of any patent or assume any such liability, and such adoption does not constitute a recommendation of any patented or proprietary application that may be involved.

FORM OF STANDARDS

Committee E-5 also is charged with the study of matters relating to the form of standards and is responsible for the Regulations Governing the Form but not the Substance of Standards. The committee wishes to report upon several matters relating to form.

The desirability of separating methods of test from specifications in so far as possible has been considered. Such a plan is in line with the general policies now being worked out by Committee E-1 on Methods of Testing and agrees with the practice of an increasing number of our standing committees. The plan is particularly applicable where a given method of test is referred to in a number of specifications, for it is then possible to publish the method of test once and include it by reference in as many specifications as desired. The plan also fits in well with the cooperative work on methods of test being carried on to an increasing degree among the standing committees. Accordingly Committee E-5 recommends the policy of separate publication of standard methods of test. It also recommends to the standing committees that methods of test, when included in specifications, shall be written as separate divisions thereof so as to facilitate their later removal from the specifications and publication as a separate standard.

There have on several occasions been discussions about the use of the metric system in standards of the Society and Committee E-5 has voted to reaffirm the present policy respecting the use of the English and metric systems in A.S.T.M. standards, set forth in the following provisions of the Regulations Governing the Form but not the Substance of Standards:

> "Units of measurement shall be expressed in both the English and metric systems, if, in the judgment of the committee concerned, it is desirable to do so. Temperatures shall be expressed in Centigrade values, and also in Fahrenheit values, if, in the judgment of the committee concerned, it is desirable to do so."

Acting upon a suggestion received from several sources, Committee E-5 has decided that hereafter the Roman numerals used in connection with sub-division headings in the standards and tentative standards of the Society shall be omitted. There is the possibility of confusing these numbers with the Arabic numbers that are used to designate successive sections of standards, particularly in telegraphic and code references to the standards. The Regulations Governing the Form but not the Substance of Standards have been amended accordingly.

MISCELLANEOUS RECOMMENDATIONS

Committee E-5 believes that the standing committees, particularly those that are responsible for a number of standards of the Society, may find it advantageous to form editorial sub-committees, which might be charged with: first, a review of present standards within the purview of the committee to improve their form and arrangement in accordance with the provisions of the Society's Regulations, to eliminate inconsistencies, and so on; and, secondly, the editorial review of proposed new standards prior to their submission to the Secretary-Treasurer for publication. Several committees of the Society have formed such sub-committees, which have been of considerable help in the editing of standards and in improving their form and clarity. The committee has accordingly requested the Secretary-Treasurer to bring this suggestion to the attention of the standing committees.

A study is being made of the possibility of developing a standard form for letter ballots of committees that will be generally adaptable to all committees and can be furnished in quantity to each committee.

This report has been submitted to letter ballot vote of the committee, which consists of 41 members; 40 members returned their ballots, all of whom have voted affirmatively.

Respectfully submitted on behalf of the committee,

C. L. WARWICK,
Chairman.

REPORT OF COMMITTEE E-6

ON

PAPERS AND PUBLICATIONS

During the year, the Committee on Papers and Publications has held two meetings, one on December 16, 1926, and the other March 1, 1927. At these meetings the general arrangements and specific details of the program of this annual meeting were discussed and at the latter meeting all offers of papers were passed upon for acceptance in accordance with the rules of the Society. Since that meeting the Advisory Committee has acted for the committee on all matters relating to the program.

The committee has followed the plan of the past few years in estimating as nearly as possible the volume of the committee reports and of accepting as many technical papers as possible to secure a well-rounded program, limiting each paper as nearly as possible to a definite size so that the total volume of the annual Proceedings, including discussions, shall be within the limitations determined by the financial budget. Under this plan of procedure the committee was able to accept most of the offers of papers including a number the committee itself solicited, although it was necessary in a number of instances to request authors of papers to shorten their papers considerably in order to keep within space limitations. It is a pleasure to record that the committee has had the cooperation of the various authors in this matter and while in some cases papers could not be kept entirely within the tentative limitations, because to do so would seriously have detracted from their value, on the whole the 32 papers on the program have been so edited as to keep within space limitations.

Two important symposiums had been planned for this annual meeting, each originating with a committee of the Society. A symposium on field control of the quality of concrete, sponsored by Committee C-9 on Concrete and Concrete Aggregates, is one of the features of the program. The other, a symposium on petroleum products and lubricants, sponsored by Committee D-2 on that subject, has been postponed until 1928 at the request of Committee D-2. The subjects to be discussed in this symposium are closely related to the work of Committee D-2 on the applications of tests for petroleum products and lubricants upon which the committee had expected to report in detail this year. It later developed that the committee's work on this subject could not be brought to a stage that would warrant more than a progress report at this annual meeting and accordingly it was deemed advisable to postpone the symposium.

The program of technical papers for the meeting includes a number that are of very general interest. As originally planned the papers were fairly well balanced between metals and non-metals; but unfortunately the authors of four papers in the non-metals field were obliged subsequently to withdraw their offers. In three of these instances the withdrawals were made so near the time of the meeting that it was not possible to secure other papers in the same field. The withdrawal of one of these papers has left the Twelfth Session on Road Materials and Waterproofing a rather short one, but it was considered inadvisable so shortly before the meeting to make any rearrangement of the program on this account.

The committee is pleased to be able to report that it has been possible to preprint practically every report and paper on the program. The funds available for preprinting this year have been sufficient and the splendid cooperation of our committee officers in submitting their reports as far in advance of the annual meeting as they could has made it possible to mail practically every committee report in advance of the meeting to all members who requested them. The authors of technical papers too were particularly helpful in furnishing manuscripts of their papers well in advance of the meeting with the result that all but one paper has been printed for the meeting. The committee feels that this is indeed a matter for congratulation and that it is the goal for which we should strive.

It is interesting to compare the volume of reports and papers for this meeting with those for the two preceding meetings. This comparison is given below:

	1925	1926	1927
REPORTS:			
Total Number	35	36	49[a]
Number of Preprints	33	32	46
Pages Preprinted	545	848	892 (est.)
PAPERS:			
Total Number	26	38	32
Number of Preprints	20	17	31
Pages Preprinted	216	258	373 (est.)

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[a] Includes reports of three joint committees and two sectional committees for which the Society is sponsor or joint sponsor under A.E.S.C. procedure.

TOTAL REPORTS AND PAPERS:			
Total Number	61	77	81
Number of Preprints	53	49	77
Pages Preprinted	761	1106	1265 (est.)

The total number of pages preprinted, estimated at 1265, is the largest for any annual meeting of the Society, although in 1924 the volume of all the reports and papers on the program exceeded that for this year.

The arrangement of the program follows in general the plan inaugurated three years ago which has proved to be satisfactory and so far as the committee knows has met with the approval of the membership. The details of presentation of reports and papers, including the observation in so far as possible of a time schedule for each session, initiated two years ago, are being followed this year.

The committee has under consideration for 1928 general discussions or symposiums on two subjects that are considered to be of much importance, namely, (1) recent developments in the production and use of light alloys and (2) wear testing of metals.

The committee has discussed certain details involved in the arrangement and editing of the Books of A.S.T.M. Standards and A.S.T.M. Tentative Standards, with particular regard to the methods of indexing those volumes.

Respectfully submitted on behalf of the committee,

C. L. WARWICK,
Chairman.

REPORT OF COMMITTEE E-8
ON
NOMENCLATURE AND DEFINITIONS

During the past year, Committee E-8 has continued its work of the review of definitions of terms and the correlation of terms prepared by the several standing committees. This work has been carried out through its sub-committees and through its special editorial committee of the Advisory Committee, which committee carries out much of the preliminary editorial review of the various definitions, and discusses suggested modifications with the standing committees concerned. In view of this method of handling the work of Committee E-8, only one meeting of the committee during the year has been required, which meeting was held on April 29. This meeting was held subsequent to the final meetings of other standing committees, which afforded an opportunity of taking action on the definitions being recommended for advancement to standard by the several standing committees.

In addition to serving as a reviewing body, the committee also acts in an advisory capacity to standing committees in the preparation of definitions. The standing committees are no longer content to prepare definitions and submit them for publication as tentative, to have them follow the usual procedure of approval and adoption, but in many instances refer the definitions to Committee E-8 while they are still in a formative or sub-tentative stage, looking to Committee E-8 for suggestions on the form of the definitions and conciseness and clarity of wording. This procedure has the advantage that the definitions so prepared are submitted as tentative in a more nearly final form. Such a procedure is one that should be encouraged to even a larger extent and Committee E-8 invites all standing committees to submit definitions to it for comment as soon as there is any suggestion that they may ultimately be submitted before the Society as tentative definitions.

In all, Committee E-8 has now approved 105 definitions as standard. It still has 144 tentative definitions before it for review and in addition there are 255 standard definitions that have not received the review and approval of the committee. The definitions submitted as tentative and those being recommended for adoption are discussed below in greater detail and the work of the several sub-committees is presented.

The outstanding feature in the work of Committee E-8 during the past year has been the number of definitions acted upon and approved for advancement to standard, This, of course, in large measure, is due to the fact that the Book of Standards is being republished this year and many committees having tentative definitions that have stood for one or more years are recommending that these definitions be advanced to standard in order that they appear in the Book of Standards. Seventy-seven definitions are being thus approved by Committee E-8 this year. With these, Committee E-8 will have approved 182 definitions of terms.

Glossary of Terms.—In view of this large number of standard definitions already approved, to which should be added the 255 definitions which had already been adopted as standard when Committee E-8 was first organized, the committee believes that a glossary of terms should now be published. The committee has had under consideration the preparation of such a glossary for the past few years but up until the present time it has been felt that the time was not yet opportune for its preparation since the general field of definitions covered by the Society's committees had not been sufficiently well reviewed.

The need for a general glossary is apparent when it is considered that many of the definitions, especially those prepared in recent years through the cooperation of Committee E-8, are of a very general nature. One of the functions of Committee E-8 is to correlate definitions and where a standing committee submits a definition that would appear to be of interest to other committees an effort is made to make such definitions sufficiently general to suit the purposes of the several committees. However, after the definitions have been made generally applicable they should be published in such a way that their general applicability will be recognized. For instance, the publication of definitions such as "clay" and allied terms should not be confined to a set of definitions entitled Definitions of Terms Relating to Hollow Tile. The publication of definitions such as "moisture," "ash," and "volatile matter," should not be confined to a set of definitions entitled Definitions of Terms Relating to Coal and Coke. Limiting the publication in this way would be to discourage the use of these general definitions by other committees, even though the definitions in their present form would suit the purposes of these other committees in every respect. By publishing a glossary the general nature of these definitions can be brought out.

It is accordingly recommended that the Society undertake during the coming year the preparation of a glossary of all standard definitions, which glossary should be included in the forthcoming Book of Standards. A similar glossary of all tentative definitions should be prepared for inclusion in the Book of Tentative Standards. This latter glossary should be revised from year to year so that the glossary appearing in the current Book of Tentative Standards would contain all of the tentative definitions of the Society.

Definitions of Terms Approved by Committee E-8

As a matter of record a complete list of the 105 terms approved by Committee E-8 is included, as given below:

- Accelerator
- Aging Coefficient
- Alloy
- Alpha Brass
- A.S.T.M. Paraffin Wax Melting Point
- A.S.T.M. Petroleum Melting Point
- Bad Start-Up
- Baggy Fabrics
- Beta Brass
- Binder
- Book Tile
- Calcined Gypsum
- Cells
- Cement
- Chafed Cord
- Clay
- Clay Separate
- Coercive Force
- Core Loss
- Corkscrew Twist
- Correction
- Crushed Gypsum
- Defective Splice
- Drying Oil
- Enamel
- End-Construction Tile
- Equi-axed Grain
- Error
- Etching Reagent
- Filler
- Fire Clay
- Float
- Foundation Tile
- Furring Tile
- Grain
- Grain Size
- Gypsum
- Gypsum Plastering Sand
- Hollow Floor Tile
- Hollow Tile
- Hollow Tile Fireproofing
- Imperfect Selvage
- Irregular Pick
- Kink
- Knot
- Knot of Finished Cord
- Lake
- Lath
- Length
- Load-Bearing Wall Tile
- Loading Range
- Macrograph
- Magnetic Permeability
- Magnification
- Metal
- Micrograph
- Mispick or Broken Pick
- Missing Cord
- Missing Warp Thread
- Mortar
- Non-Drying Oil
- Normal Induction
- Organic Acetone Extract
- Partition Tile
- Percentage of Error
- Plaster
- Porous Hollow Tile
- Pucker
- Reed Mark
- Residual Induction
- Retarder
- Salt-Glazed Tile
- Saponifiable Acetone Extract
- Scoring
- Semi-Drying Oil
- Sewed Thread
- Shale
- Shell
- Side-Construction Tile
- Size
- Sized Gypsum
- Slack and Tight Warp or Filling Threads
- Slack and Tight Cords
- Slug
- Smash
- Split Tile
- Split or Chafed Yarn
- Standard Core Loss
- Stucco
- Surface Clay
- Testing Machine
- Thick and Thin Places (Major)
- Thick and Thin Places (Minor)
- Thickness
- Thin Places (Major)
- Thin Places (Minor)
- Tolerance
- Toner
- Total Waxy Hydrocarbons
- Unsaponifiable Resins
- Varnish
- Webs
- Width
- Wood Fiber
- Wrong Draw

In addition to the 94 terms listed in the report of the committee for 1926, the above list includes 11 additional terms adopted at the 1926 annual meeting.

TENTATIVE DEFINITIONS BEFORE COMMITTEE E-8

As mentioned above, 11 tentative definitions were adopted as standard at the 1926 annual meeting. Sixty-eight new tentative definitions were submitted as follows:

Definitions Relating to Magnetic Properties of Iron and Steel:

Normal Induction
Magnetic Permeability
Residual Induction
Coercive Force
Core Loss
Standard Core Loss
Aging Coefficient

Definitions Relating to Gypsum:

Gypsum Pottery Plaster
Gypsum Molding Plaster
Keene's Cement

Definitions of Terms Relating to Insulating Materials:

Insulation Resistance
Volume Resistance
Surface Resistance
Surface Resistivity
Volume Resistivity

Definitions of Terms Relating to Textile Materials:

Thick and Thin Places (Major Defects)
Thick and Thin Places (Minor Defects)
Missing Warp (Yarn or Cord)
Pucker (Puff or Blister)
Bad Start-Up
Knot
Slack and Tight Warp or Filling Yarns or Cords
Slug
Sewed Yarn
Corkscrew Twist
Mispick or Broken Pick
Float
Kink
Reed Mark
Split or Chafed Yarn or Cord
Dirty Yarn
Wrong Ply Warp (Yarn or Cord)
Wrong Draw
Oil Spot
Mixed Yarn of Inferior Grade
Irregular Pick
Smash
Imperfect Selvage
Baggy Fabric
Wrong Ply Filling Yarn
Mixed Yarn or Cord
Defective Splice
Standard Atmosphere
Standard Condition
Regain (Moisture Regain)
Standard Regain
Standard Weight
Moisture Content
Yarn
Cord
Thread
Lea
Count
Ends
Picks
Gage
Plain Weave
Twist, Direction of
Rayon
Rayon Yarns
Spun Rayon
Nitro-Cellulose Rayon (Chardonnet)
Viscose Rayon
Cuprammonium Rayon
Cellulose-Acetate Rayon
Direction of Twist

Miscellaneous Terms:

Slate
Metallography

Sixteen definitions were withdrawn as follows:

Definitions of Terms Relating to Timber:

Annual Ring
Dense Douglas Fir
Diagonal Grain
Encased Knot
Loose Knot
Ring Shake
Rotten Knot
Round Shake
Sound and Tight Knot
Summer Wood

Definitions of Terms Relating to Coke:

Gas House Coke
Domestic Coke
Foundry Coke from Beehive Ovens
Foundry Coke from By-Product Ovens
Furnace Coke from Beehive Ovens
Furnace Coke from By-Product Ovens

This left 144 tentative definitions before Committee E-8 for consideration. Grouped below according to subject matter the present status of these definitions is indicated.

Terms Relating to Coal and Coke (D 121).—The 11 terms defined by Committee D-5 on Coal and Coke are as follows:

Proximate Analysis
Ultimate Analysis
Moisture
Ash
Volatile Matter
Fixed Carbon
Coke
Beehive Coke
By-Product Coke
Coke Breeze
Dry Coke

The definitions of the terms "moisture," "ash," "volatile matter" and "fixed carbon" have been revised as recommended by the Sub-Committee on Moisture, Ash, etc., as reported upon in connection with the activities of that sub-committee. The definitions are being recommended for advancement to standard by Committee D-5, together with the definitions for "proximate analysis" and "ultimate analysis" which latter two definitions were reviewed by the Advisory Committee and agreement reached with Committee D-5 on the wording being recommended for advancement to standard.

The remaining 5 definitions are being continued as tentative since the committee wishes to give them further consideration.

Terms Relating to Gypsum (C 11, C 22, C 23, C 36, C 37, C 52, C 59, C 60, C 61).—The 9 terms in these standards as defined by Committee C-11 on Gypsum, are as follows:

Aggregate
Consistency
Gypsum Partition Tile or Block
Gypsum Plaster Board
Gypsum Wall Board
Plasticity
Gypsum Molding Plaster
Gypsum Pottery Plaster
Keene's Cement

While substantial agreement has been reached on definitions of several of the terms listed above, no agreement has yet been reached concerning the definitions of the remaining terms. For instance, the definition for "aggregate" falls under the jurisdiction of the Sub-Committee on Sand and Aggregate and a final report of this sub-committee has not yet been presented. The definitions for the terms "consistency," and "plasticity" await the findings of a Sub-Committee, of Committee E-1 on Methods of Testing, on Consistency, Plasticity, etc. This latter sub-committee has made some progress on the consideration of these terms and a report should be forthcoming during the year. It is understood that Committee C-11 will continue all of the definitions as tentative for the time being.

Terms Relating to Lime (*C 51, C 25*).—The 7 terms defined by Committee C-7 on Lime are as follows:

Quicklime
Hydrated Lime
In Bulk
Lump Lime
Lump Lime Screened
Pulverized Lime
Available Lime

Committee E-8 gave these definitions an editorial review, and since Committee C-7 appeared to be the only standing committee interested, the definitions were referred to that committee only, with a number of suggestions for rewording. Committee E-8 questioned the utility and the need for the definition of the term "in bulk" and referred the matter to Committee C-7 for advice. It is understood that Committee C-7 plans to withdraw this definition.

The remaining definitions have been revised and are in substantially the form recommended by Committee E-8. The definitions, however, are not being recommended for advancement to standard this year, and accordingly no letter ballot on their approval has as yet been conducted in Committee E-8.

Terms Relating to Waterproofing Materials (*D 147*).—The 3 definitions submitted by Committee D-8 on Bitumiuous Waterproofing and Roofing Materials are as follows:

Asphalt Mastic
Asphalt Mastic Cake
Bituminous Grout

Committee E-8 and Committee D-8 arrived at an agreement on the wording of the definitions. However, at the meeting of Committee E-8, when the definitions came up for consideration it was recommended that the definition for "asphalt mastic" be amended slightly by changing the phrase "requires *a trowel* to form it into a compact mass" to read "requires *trowelling* to form it into a compact mass." The definitions, with this slight change, have been approved by Committee E-8.

Terms Relating to Textiles.—At the 1926 annual meeting, Committee D-13 on Textile Materials recommended that all the definitions of terms relating to textile materials (with the exception of 8 new definitions of terms relating to rayon which are mentioned separately below) be grouped in one document. To accomplish this, the definitions formerly appearing in its several specifications were removed from those specifications and added to its Tentative Definitions of Terms Relating to Textile Materials (D 123). In addition, the committee recommended a number of new tentative definitions. The complete list of the 62 definitions is as follows:

Thick and Thin Places (Major Defects)
Thick and Thin Places (Minor Defects)
Missing Warp (Yarn or Cord)
Pucker (Puff or Blister)
Bad Start-Up
Knot
Slack and Tight Warp or Filling Yarns or Cords
Slug
Sewed Yarn
Corkscrew Twist
Mispick or Broken Pick
Float
Kink
Reed Mark
Split or Chafed Yarn or Cord
Dirty Yarn
Wrong Ply Warp (Yarn or Cord)
Wrong Draw
Oil Spot
Mixed Yarn of Inferior Grade
Irregular Pick
Smash
Imperfect Selvage
Baggy Fabric
Wrong Ply Filling Yarn
Mixed Yarn or Cord
Defective Splice
Mechanical Fabric
Tire Builder Fabric
Tire Cord Fabric
Hose Duck
Rubber Belt Duck
Balata Belt Duck
Oil Belt Duck
Numbered Duck
Army Duck
Single Filled or Flat Duck
Enameling Duck
Twill
Drills
Alberts
Jeans
Serge
Clay
Standard Atmosphere
Standard Condition
Regain (Moisture Regain)
Standard Regain
Standard Weight
Moisture Content
Yarn
Cord
Thread
Lea
Count
Ends
Picks
Gage
Plain Weave
Twist, Direction of
Crimp
Off-Square

Of these, 6 terms are included which are described as requiring no definition, namely, the terms:

Dirty Yarn
Wrong Ply Warp (Yarn or Cord)
Oil Spot
Mixed Yarn of Inferior Grade
Wrong Ply Filling Yarn
Mixed Yarn or Cord

To this should be added the term "bad start-up" since this has been similarly classified during the year.

In addition, a tentative definition for "direction of twist" appears in the Tentative Specifications for Tolerences and Test Methods for Cotton Yarns, Single and Plied (D 180) and in the Tentative Specifications for Tolerances and Test Methods for Cotton Sewing Threads (D 204).

The definitions with the exception of the 7 mentioned above as being classed as not requiring definition, have been reviewed during the year and with the exception of the definitions for the terms "regain (moisture regain)" and "gage" and the definitions relating to rayon, agreement has been reached with Committee D-13 concerning the wording of the definitions and they are being recommended for advancement to standard as given in the current report of Committee D-13.

The 8 definitions relating to rayon appearing in the Tentative Specifications for Tolerances and Test Methods for Rayon (D 258) are as follows and these are still under consideration by Committee D-13 and in the Advisory Committee of Committee E-8.

Rayon
Rayon Yarns
Spun Rayon
Nitro-Cellulose Rayon (Chardonnet)
Viscose Rayon
Cuprammonium Rayon
Cellulose-Acetate Rayon
Direction of Twist

No action concerning them, however, is being recommended at this time.

Terms Relating to Paint.—Committee D-1 on Preservative Coatings for Structural Materials has still before it 3 tentative definitions, namely, definitions for the terms "toughness," "elasticity of paint and varnish films" and "screen (sieve)." No action in regard to these definitions is being recommended this year by Committee D-1.

Terms Relating to Petroleum Products.—The following 6 definitions of terms appear in the methods of test prepared by Committee D-2 on Petroleum Products and Lubricants:

Alkali Neutralization Number (D 188)
A.S.T.M. Precipitation Number of Lubricating Oils (D 91)
Cloud Point (D 97)
Mineral Acid Neutralization Number (D 188)
Neutralization Number (D 188)
Pour Point (D 97)

These definitions are being discussed with Committee D-2. No action is being recommended concerning them this year.

Definition of the Term Slate.—Committee D-16 on Slate submitted at the 1926 annual meeting for publication as tentaive a definition for the term "slate" which had already received the consideration of Committee E-8. The definition has since been modified slightly in the light of comments of the Advisory Committee and is being recommended for advancement to standard this year by Committee D-16 with the approval of Committee E-8.

Terms Relating to Methods of Testing.—Definitions for the following 8 terms, prepared by Committee E-1 on Methods of Testing, appear in the Tentative Definitions of Terms Relating to Methods of Testing (E 6), in the Tentative Methods of Compression Testing of Metallic Materials (E 9), and in the Tentative Methods of Tension Testing of Metallic Materials (E 8).

Stress
Strain
Stress-Strain Diagram
Elastic Limit
Yield Point
Tensile Strength
Compressive Strength
Modulus of Elasticity

These have already been brought in line with the recommendations of the Advisory Committee. They were recommended for advancement to standard this year by Committee E-1 but it developed that possibly there should be some further interchange of ideas and a further study of the leading sources of technical literature in this country made in order that the practice in the use of terms might be made as uniform as possible. It was accordingly recommended by Committee E-8 that the definitions be continued as tentative for the time being.

Definition of the Term Metallography.—Committee E-4 on Metallography presented as tentative a definition for the term "metallography" at the 1926 annual meeting. This definition has been reviewed and agreement has been reached between the Advisory Committee and Committee E-4 on a satisfactory wording, which is being recommended for advancement to standard by Committee E-4 with the approval of Committee E-8.

Terms Relating to Insulating Materials.—Committee D-9 on Electrical Insulating Materials included in its Tentative Methods of Test for Surface Resistivity and Volume Resistivity of Solid Insulating Materials (D 257), definitions for the following 5 terms:

Insulation Resistance
Volume Resistance
Surface Resistance
Volume Resistivity
Surface Resistivity

These definitions were reviewed by the Advisory Committee and modifications suggested by Committee D-9, which, it is understood, are acceptable to that committee. No action in regard to these definitions is being recommended this year by Committee D-9 looking toward their advancement to standard.

Terms Relating to Magnetic Testing.—Committee A-6 on Magnetic Properties included in its Tentative Methods of Test for Magnetic Properties of Iron and Steel (A 34 T) definitions for the following 7 terms:

Normal Induction
Magnetic Permeability
Residual Induction
Coercive Force
Core Loss
Standard Core Loss
Aging Coefficient

These were reviewed during the year and agreement was reached in regard to their wording between the Advisory Committee and Committee A-6. They are being recommended for advancement to standard this year by Committee A-6 with the approval of Committee E-8 to supersede corresponding definitions for the same terms now appearing in the Standard Methods of Magnetic Properties of Iron and Steel (A 34).

Miscellaneous Terms.—There are 11 terms classed as miscellaneous:

Absolute Specific Gravity (of solids and liquids) (E 12)
Annealing (A 95)
Apparent Specific Gravity (of solids) (E 12)
Bulk Specific Gravity (of solids) (E 12)
Concrete Brick (C 55)
Ductility (D 113)
Normalizing (A 95)
Sand (C 58)
Screen (Sieve) (E 13)
Specific Gravity (of solids and liquids) (E 12)
Specific Gravity (D 70, D 71)

Of these, the definitions for the terms "sand," "screen (sieve)," "absolute specific gravity (of solids and liquids)," "apparent specific gravity (of solids)," "bulk specific gravity (of solids)" and "specific gravity (of solids and liquids)" are discussed under the activities of the several sub-committees. The description of ductility (D 113) (as given by Committee D-4 on Road and Paving Materials) as applying to the ductility of asphalt cement, and the statements on specific gravity appearing in Methods D 70 and D 71 (prepared by Committee D-4), were considered by the Advisory Committee to be not definitions and Committee D-4 was so advised. The definition for "concrete brick" was presented in 1924 by Committee C-3 on Brick and has received the consideration of Committee E-8.

Definitions Submitted as Information

Some of the standing committees of the Society have submitted in their reports definitions put forth to solicit comments and suggestions or have submitted these definitions direct to Committee E-8 for comment.

Terms Relating to Heat Treatment.—The American Society for Steel Treating prepared a series of definitions of terms relating to heat treatment which was referred to a number of organizations including the A.S.T.M. for criticism. The definitions were accordingly referred to Committee A-4 on Heat Treatment of Iron and Steel. This committee, in submitting a number of comments, for transmission to the A.S.S.T., recommended that a joint committee of nine be appointed to consist of three representatives of each of the following organizations: American Society for Steel Treating, Society of Automotive Engineers and the American Society for Testing Materials. This Joint Committee was duly organized and prepared a series of definitions relating to heat treatment operations. These are being submitted this year by Committee A-4 for acceptance for publication as tentative.

Definition of the Term Brick.—Committee C-3 on Brick prepared a definition for the term "brick" which term was submitted to Committee E-8 for comment. The Advisory Committee informally submitted a number of suggestions to Committee C-3 and Committee E-8 has since further cooperated in the preparation of a modification of the definition.

ACTIVITIES OF SUB-COMMITTEES

Sub-Committee on Specific Gravity.—The Sub-Committee on Specific Gravity, under the chairmanship of F. M. Farmer, presented in 1925 for publication as tentative, definitions for the terms "absolute specific gravity (of solids and liquids)," "apparent specific gravity (of solids)," "bulk specific gravity (of solids)," and "specific gravity (of solids and liquids)." These definitions were reviewed during the subsequent year and in 1926 slight modifications of the definitions were recommended. The definitions, which were last published under the title Tentative Definitions of Terms Relating to Specific Gravity (E 12 - 26 T)[1] are now being recommended by the sub-committee for advancement to standard, which recommendation is concurred in by Committee E-8.

Sub-Committee on Moisture, Ash, Volatile Matter and Fixed Carbon.—The Sub-Committee on Moisture, Ash, etc., under the chairmanship of H. C. Porter, presented in 1926 definitions for the terms "moisture," "ash," "volatile matter" and "fixed carbon" which definitions were published as information in the report of Committee E-8. The definitions have been modified slightly during the year and are now being recommended for advancement to standard by Committee D-5 on Coal and Coke, the committee responsible for their original submission. The definitions in their final form read as follows:

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 26, Part I, p. 1089 (1926); also 1926 Book of A.S.T.M. Tentative Standards, p. 990.

"*Moisture.*—Essentially water, quantitatively determined by definite prescribed methods which may vary according to the nature of the material.

"*Note.*—Such methods may not determine all of the water present."

"*Ash.*—Inorganic residue remaining after ignition of combustible substances, determined by definite prescribed methods.

"*Note.*—Ash may not be identical, in composition or quantity, with the inorganic substances present in the material before ignition."

"*Volatile Matter.*—Those products, exclusive of moisture, given off by a material as gas or vapor, determined by definite prescribed methods which may vary according to the nature of the material."

"*Fixed Carbon.*—In the case of coal, coke and bituminous materials, the solid residue, other than ash, obtained by destructive distillation, determined by definite prescribed methods.

"*Note 1.*—It is made up principally of carbon, but may contain appreciable amounts of sulfur, hydrogen, nitrogen and oxygen."

This accordingly represents the final report of the sub-committee.

Sub-Committee on Definitions of the Terms Sieve and Screen.—This sub-committee, under the chairmanship of L. R. Ferguson, presented at the 1926 annual meeting a modification of its definition for "screen (sieve)" accepted for publication as tentative in 1925. This modification was further revised on the floor of the meeting to read as follows:

"*Screen (Sieve).*—A plate or sheet or a woven cloth, with regularly spaced apertures of uniform size, mounted on a suitable frame or holder, for use in separating materials according to size.

"*Note 1.*—The shape and spacing of apertures, size of wires or threads, thickness of plate or sheet, allowable variations and similar properties, should be taken care of in specifications.

"*Note 2.*—In mechanical analysis testing work, the term 'sieve' when not specifically defined in connection therewith, shall apply to an apparatus in which the apertures are rectangular. The term 'screen' when not specifically defined in connection therewith, shall apply to an apparatus in which the apertures are circular."

In the light of criticisms of the Editorial Committee, it is recommended that Note 2 of the definition be simplified to read as follows:

"*Note 2.*—In mechanical analysis testing work, when not otherwise specified, the term 'sieve' shall apply to an apparatus in which the apertures are rectangular, and the term 'screen' shall apply to an apparatus in which the apertures are circular."

This can be considered an editorial change rather than a definite revision.

Sub-Committee on Sand and Aggregate.—This sub-committee, under the chairmanship of L. R. Ferguson, recommended a revised wording for the definition for the term "sand" (Serial Designation: C 58) which was accepted at the 1926 annual meeting, to read as follows:

"*Sand.*—The fine granular material (usually less than ¼ in. in diameter) resulting from the natural disintegration of rock, or from the crushing of friable sandstone rocks.

"*Note.*—When used without a qualifying adjective, 'sand' is generally understood to mean the product of the natural disintegration of siliceous or calcareous rock. Sand should be distinguished from screenings, gravel, etc. The size of particle and other physical characteristics should be taken care of in specifications. The fine material resulting from the crushing of blast-furnace slag is known as 'slag sand.'"

The following definition for the term "aggregate" was accepted in 1926 for publication as tentative:

"*Aggregate.*—Designated inert material, which when bound together into an agglomerated mass by a matrix forms concrete, mastic, mortar, plaster, etc."

Several minor criticisms have been under consideration during the year but no recommendations are offered with the exception that the word "agglomerated" in the definition be changed to "conglomerate."

The sub-committee has had referred to it the question of the preparation of definitions for the terms "crushed gravel" and "screened crushed gravel," the suggestion that definitions for these terms be prepared having been received from Committee D-4 on Road and Paving Materials.

Sub-Committee on Concrete.—This sub-committee, under the chairmanship of L. R. Ferguson, prepared a definition for the term "concrete" which was included as information in the 1926 Report of Committee E-8, reading as follows:

"*Concrete.*—A combination of aggregate or aggregates with a binding medium which, after mixing, solidifies into a conglomerate mass.

"*Note.*—In the present state of the art, the term 'concrete,' when used without a qualifying adjective, is understood to mean portland-cement concrete."

No recommendation is offered for modifications in this definition or any actions concerning it. The definition is accordingly continued as information.

The approval of the definitions being recommended for advancement to standard and the recommendations appearing in this report have been referred to letter ballot of the committee with the following results:

Items	Affirmative	Negative	Not Voting
I. ADVANCEMENT TO STANDARD OF TENTATIVE DEFINITIONS			
1. Tentative Definitions of Terms Relating to Specific Gravity (E 12 - 26 T)	31	1	15
II. APPROVAL OF ADVANCEMENT TO STANDARD OF TENTATIVE DEFINITIONS, RECOMMENDED BY STANDING COMMITTEES			
2. Definitions of Terms Relating to Coal and Coke, Recommended by Committee D-5:			
Moisture	26	0	21
Ash	25	0	22
Volatile Matter	25	0	22
Fixed Carbon	25	0	22
Proximate Analysis	25	0	22
Ultimate Analysis	25	0	22
3. Definitions of Terms Relating to Magnetic Properties of Iron and Steel, Recommended by Committee A-6	22	0	25
4. Definitions of Terms Relating to Waterproofing Materials, Recommended by Committee D-8:			
Bituminous Grout	20	0	27
Asphalt Mastic	20	0	27
Asphalt Mastic Cake	19	1	27
5. Definitions of Terms Relating to Textile Materials, Recommended by Committee D-13	20	0	27
6. Definition of the Term Metallography, Recommended by Committee E-4	24	1	22
7. Definition of the Term Slate, Recommended by Committee D-16	21	0	24

This report has been submitted to letter ballot of the committee, which consists of 47 members, with the following results: Advisory Committee, 6 affirmative, 0 negative, 1 not voting, total, 7. Standing Committees, 31 affirmative, 0 negative, 9 not voting, total 40.

Respectfully submitted on behalf of the committee,

CLOYD M. CHAPMAN,
Chairman.

R. E. HESS,
Ex-Officio Secretary.

EDITORIAL NOTE

The Tentative Definitions of Terms Relating to Specific Gravity were approved at the annual meeting and subsequently adopted by letter ballot of the Society on September 1, 1927. The definitions appear in the 1927 Book of A.S.T.M. Standards, Parts I and II.

REPORT OF COMMITTEE E-9
ON
CORRELATION OF RESEARCH

During the current year the committee has held one meeting on April 12, 1927, in the Society rooms at Philadelphia.

During the year the "List of Current and Proposed Researches and Investigations by A.S.T.M. Committees" has been kept abreast of the reported work of the various standing committees. This list is in card index form, classified according to subject, with complete cross-references, and according to methods of administration of the particular research project, that is (1) projects administered by A.S.T.M. standing committees, (2) projects administered by A.S.T.M. research committees, (3) projects administered by joint committees sponsored by the Society, and (4) projects sponsored by other organizations upon whose committees the Society is represented. This index is on file in the Secretary's office and has been invaluable in outlining the activities of the committee.

There is appended to this report a list of the titles and brief statements of the various research projects classified as indicated above, from which the volume and extent of the research work now being done under the auspices of the Society is apparent. With one or two exceptions the list does not include new researches initiated since the 1926 annual meeting. Information regarding the status of the projects is maintained by the committee and will gladly be furnished to any member or committee of the Society upon request. Most of these projects are active.

Research Committees of the Society:

Research Committee on Effect of Tin and Arsenic on High-Speed Tool Steels.—This committee reports progress this year, and has submitted a definite outline of proposed work, including a considerable compilation of data from geological reports concerning the content of arsenic and tin found in various ores used in the manufacture of high-speed tool steel.

Joint Research Committee on Effect of Temperature on the Properties of Metals.—During the year this committee functioning under the joint auspices of this Society and the American Society of Mechanical Engineers has added members to its number to cover certain definite fields of use of metals under high temperatures, and has carried out a good part of a series of short-time tension tests of various steels under rather wide ranges of temperature. A progress report is on the program of this annual meeting. Further work has reached the stage of definite plans, and ways and means for carrying this work on are being devised. The committee is functioning actively.

Research Committee on Yield Point of Structural Steel.—This committee has been very active indeed during the year. The first series of tests, designed to be a study of effect of speed of testing on yield point, has been carried out and the data have been tabulated. This series of tests indicated that with uniform material and careful testing technique, the values for yield point obtained by different laboratories and by different methods gave quite consistent results. The committee has a second series of tests planned, and it is hoped to carry them out during the year. Committee E-9 wishes to express its appreciation of the excellent start which the Research Committee on Yield Point of Structural Steel has made on its task.

Study of Corrosion-Resistant Alloys:

At the suggestion of Committee E-9, Committees A-5 on Corrosion of Iron and Steel and B-3 on Corrosion of Non-Ferrous Metals and Alloys have formed a joint advisory committee to consider the method and scope of work to be undertaken by these two committees in the field of corrosion-resistant alloys. There is general agreement on the importance of the study of these alloys, particularly as concerns their resistance to corrosion, and the problem merits the consideration of the two corrosion committees of the Society.

Proposed Research on Mineral Aggregates:

The need of further knowledge of the general properties of mineral aggregates was called to the attention of the committee during the 1926 annual meeting, and the committee has circularized a number of users of mineral aggregates, several technical societies and one or two Government bureaus to see whether there was need of a general investigation of mineral aggregates, and if so how it could best be handled. The consensus of the replies seemed to indicate that there was need of much more knowledge of the properties of mineral aggregates, but that various parts of the field were already under study by existing organizations, and that it was doubtful whether the organization of a general investigation on the subject would be feasible or helpful at this time.

Cooperation with North Carolina Highway Board:

The Highway Board of the state of North Carolina has asked the cooperation of the Society, through Committee E-9, in a test to destruction of a reinforced-concrete highway bridge which would be submerged in a lake to be formed in developing a water power project. Committee E-9 has asked F. E. Schmitt, one of its members, to keep in touch with this project and to report to the committee when it has assumed definite shape.

The General Status of Research Work in the A.S.T.M.:

Judging by reports from the standing committees and by comment in the technical press, both domestic and foreign, there seems to be throughout the society a healthy interest in what may be called the "research" side of its work as well as in what may be called the "standardization" side. This state of affairs is a matter for congratulation, and should be a spur to still further work.

Committee E-9 would like to have each standing committee of the society consider the following questions in relation to its work:

What work is being done in exploring the unknown regions in the field of your committee work?

Should research work in the "unknown regions" be undertaken by the present committee or should a separate research committee be organized?

Do the standard tests used in your field of work give reliable indications of the service qualities of the materials in that field? Should there be research work carried on for the purpose of devising better tests?

Respectfully submitted on behalf of the committee,

H. F. MOORE,
Chairman.

C. L. WARWICK,
Secretary.

APPENDIX

LIST OF A.S.T.M. RESEARCH PROJECTS

There is given below a list of A.S.T.M. research projects under the following classifications:

1. Projects administered by A.S.T.M. standing committees;
2. Projects administered by A.S.T.M. research committees;
3. Projects administered by joint committees sponsored by the Society.

In general, this list records projects as of the date of the annual meeting of the Society in 1926 and does not include projects that may have been initiated by the standing committees since that meeting.

The projects are listed by brief title and index classification and in most instances there are given brief statements of the scopes of the projects. A more complete statement of the scope of each project, the manner of its administration and its present status is on file at the headquarters of the Society and information relating thereto will gladly be furnished to any committee or member of the Society upon request.

The standing committees of the Society whose names do not appear in the list fall in two classes: first, those whose activities have not involved any research in materials; and second, those that are devoting their major attention to methods of testing, in connection with which they are conducting many investigations (some of considerable magnitude) but which are not intended primarily to promote knowledge of the materials with which the committees are working and do not lend themselves to listing as specific projects. Information regarding the investigative work of such committees is, however, included in the files in the Secretary-Treasurer's office and is available for consultation.

PROJECTS ADMINISTERED BY A.S.T.M. STANDING COMMITTEES

Committee A-1 on Steel:

S 1. Concrete Reinforcement Bars (jointly with Committee C-2).

Investigation of the physical properties of concrete reinforcement bars, plain, deformed and twisted, rolled from four different grades of steel now in commercial use, in the form as rolled and in machined test specimens; also an investigation of the efficiency of deformed bars when used as reinforcing in concrete, with special reference to the effect of the design of the bar on its bond resistance.

S 2. Effect on Properties of Forgings of Amount of Reduction Between Ingot and Bloom.

Effect on properties of forgings of amount of reduction between ingot and bloom. Includes tests of blooms with reductions from the ingot of two to one, three to one and four to one, both without treatment and annealed; also tests of rounds of several diameters, both pressed and hammered from billets made from the blooms.

S 42. Study of Single Versus Double Welding of Lap-Welded Steel Pipe.

A study of the relative efficiency and economy of single versus double welded pipe for flanging. The results of this investigation will have a direct bearing on specification requirements.

Committee A-2 on Wrought Iron:

S 3. Quality of Wrought Iron as Influenced by Manufacture and Heat Treatment.

Quality of wrought iron as influenced by manufacture and heat treatment. It is particularly contemplated to study the influence of raw material and processes of manufacture on puddled wrought iron.

S 4. Annealing of Wrought Iron Chain (jointly with Committee A-4).

Effect of heat treatment of wrought iron in special cases, such as chain and other articles where the metal has been brought to a high temperature for welding; including the desirability of annealing iron chain at intervals; also red shortness of wrought iron when subjected to mechanical work at temperatures around 1500° F.

Committee A-3 on Cast Iron:

S 5. Arbitration Test Bar for Cast Iron.

Study of test bars for cast iron from an international viewpoint. The object is to provide means of testing cast iron products for export only, and no interference with the customs of the industry in the several countries is urged or contemplated.

Committee A-4 on Heat Treatment of Iron and Steel:

S 4. Annealing of Wrought Iron Chain (jointly with Committee A-2).

Committee A-5 on Corrosion of Iron and Steel:

S 6. Atmospheric Corrosion Tests of Uncoated Sheets.

Exposure tests of bare (uncoated) steel and iron sheets under atmospheric conditions at Pittsburgh, Fort Sheridan and Annapolis.

S 7. Total Immersion Tests of Uncoated Sheets.

Tests of bare (uncoated) steel and iron sheets totally immersed in acid mine water at Calumet, Pa., in saline water at Annapolis, in city water at Washington. Also tests in open ocean water to determine the effect of corrosion on steel ship plate with and without copper when riveted with rivets of iron and steel with varying copper contents.

S 8. Atmospheric Corrosion Tests of Metallic Coated Products.

Comprehensive field tests at several locations representing varying atmospheric conditions on metal products coated by various processes, e.g., hot-dipped galvanized sheets, wire products, structural shapes and castings; sherardized castings; electrozinc plated castings; zinc-coated sprayed castings and structural shapes; terne-coated sheets; lead-coated sheets; cadmium-plated castings; and calorized castings. An important purpose of the tests is to correlate results of service with various types of laboratory, including accelerated, tests.

S 9. Accelerated Corrosion Tests.

Study of various methods of accelerated corrosion tests with particular reference to their application to metallic coated products. Related to the atmospheric exposure tests mentioned in S 6 and S 8. The main purpose is to find some tests which will give results indicative of what really occurs in service.

Committee A-8 on Magnetic Analysis:

S 10. Study of Magnetic Properties of Steel and Their Correlation with Other Properties and with General Performance.

Study of magnetic properties of steel and their correlation with other properties and with general performance. This expresses briefly the aim of the committee in all of its work.

Committee B-2 on Non-Ferrous Metals and Alloys:

S 11. Test Bars for Cast Non-Ferrous Alloys.

A study of the best type of test bars for various cast non-ferrous alloys. The relationship between properties of the test bars and properties of the metal in the castings they represent is involved in this project.

S 12. General Study of Properties of Babbitt Metal.

This project includes determination of physical properties of white metal bearing alloys in the A.S.T.M. tentative standards; correct pouring temperatures of Babbitt metal; effect of ratio of length to diameter in compression testing of Babbitt metal; and effect of impurities on the properties of Babbitt metal, such as friction and wearing properties, fluidity, brittleness, and amount of drossing.

Committee B-3 on Corrosion of Non-Ferrous Metals and Alloys:

S 13. Standardization of the Practice of Corrosion-Resistance Testing.

A study of four corrosion tests, viz., total immersion, alternate immersion, spray, and accelerated electrolytic. Six non-ferrous metals will be tested by a number of cooperating laboratories each following carefully prescribed methods and reporting data on standardized forms.

Committee C-1 on Cement:

S 14. Compressive Strength Test of Cement Mortars.

Development of satisfactory commercial test for compressive strength of portland-cement mortars. Specification requirements are involved.

S 15. Development of Shorter Time Strength Test.

Consideration of suggestion that a three-day or four-day mortar strength test be developed for portland cement.

S 16. Sulfuric Anhydride and Magnesia Content of Cement.

Consideration of proposed changes in requirements for sulfuric anhydride and magnesia in portland cement.

S 43. Fluid Cement-Water Mixtures.

This project includes (1) tension and compression tests of fluid portland cement-water mixtures, including day-to-day uniformity of strength test, effect of varying quantity of mixing water and study of flow cylinder test for consistency of fluid cement-water mixtures; and (2) a study of the possibilities of a one or three-day strength test for portland cement.

Committee C-2 on Reinforced Concrete:

S 1. Concrete Reinforcement Bars (jointly with Committee A-1).

Committee C-3 on Brick:

S 18. Study of Test for Compressive Strength of Brick.

S 19. Present Condition of Bricks in Old Buildings.

To obtain, record and correlate information about the present condition of bricks in old buildings.

Committee C-4 on Clay and Cement-Concrete Sewer Pipe:

S 20. Chemical Test Requirements for Sewer Pipe.

To determine resistance of clay and cement-concrete sewer pipe to chemical actions. (The problem is being approached largely from the point of view of specification requirements.)

Committee C-6 on Drain Tile:

S 21. Chemical Test Requirements for Drain Tile.

Development of chemical tests and chemical test requirements for drain tile to determine their resistance to the action of alkalies and acids in the soil. (In cooperation with other organizations.)

Committee C-7 on Lime:

S 22. Cause of Plasticity.

A general investigation of the property of plasticity as relates to lime and lime products. Includes a study of relation between plasticity of lime-sand mortar and sand-carrying capacity of lime.

Committee C-9 on Concrete and Concrete Aggregates:

S 23. Design of Concrete.

Analyzing the existing data on various theories of proportioning concrete mixtures, and of developing an adequate theory of design.

S 36. Field Tests of Concrete.

Standardization of methods of making field specimens, including sampling of the concrete when soft, the methods of sampling hardened concrete, and the development of field tests for concrete. Investigation of the relations that may exist between the strengths of test specimens of different forms and dimensions. Relation between the compressive strength of test cylinders made in accordance with the A.S.T.M. standard method and prisms removed from slabs of the same mix.

S 37. Available Aggregates for Concrete.

S 38. Deleterious Substances in Concrete.

A study of the various naturally or accidentally occurring materials in concrete which may affect it deleteriously.

S 39. Admixtures.

A general study of admixtures which may be added to concrete for the purpose of improving some of its properties.

S 40. Conditions Affecting Durability of Concrete in Structures.

Study of the conditions under which concrete has not been durable. It will emphasize the precautions which must be taken to produce good concrete, whether in methods, materials or workmanship.

S 41. Elastic Properties of Concrete.

Studies of the elastic properties of concretes of different mixtures at different ages under different conditions of moisture, the effect of different aggregates, a determination of the modulus of elasticity of concrete in tension, establishment of Poisson's ratio, and establishment of the effect of brief application of loads including loads applied suddenly or with impact; also studies of the form of specimens, type of bearing, rate of application of load, sensitivity of measuring devices, etc.

Committee D-1 on Preservative Coatings for Structural Materials:

S 24. Paint Vehicles.

General studies of properties and methods of tests of paint vehicles, such as linseed oil, tung oil, soya bean oil, etc.

S 25. Varnish.

General studies of properties and methods of tests of varnish.

S 26. Turpentine and Other Paint Thinners.

General studies of properties and methods of tests of turpentine and other paint thinners.

S 27. Shellac.

General studies of properties and methods of tests of shellac and shellac varnish. Most of the sub-committee's work is expected to lead to standard specifications and methods of test.

S 28. Preparation of Iron and Steel Surfaces for Painting.

Study of influence of various methods of preparing iron and steel surfaces upon the life of painted sheets, under atmospheric exposure.

S 29. Anti-Corrosive and Anti-Fouling Paints.

Study of the value of various anti-corrosive and anti-fouling paints.

S 30. Physical Properties of Paint Materials.

A study of the physical problems connected with paints and paint materials. Viscosity and plasticity of paints and color and optical properties of paints and paint materials have first been considered.

Committee D-11 on Rubber Products:

S 31. Performance Tests of Rubber Products.

To develop suitable performance tests for rubber products and to determine the practicability of introducing such tests into specifications. Accelerated aging test, abrasion tests, oil and gasoline tests and durability tests for belting are being studied.

Committee D-14 on Screen Wire Cloth:

S 32. Relative Life of Various Screen Wire Cloth.

To determine the relative life of the higher grade screen wire cloths when exposed to various atmospheric agencies, such as corrosion and wind, as they exist in different localities and climates, so that purchasers of such material may make an economic selection best suited to their particular conditions.

Committee E-4 on Metallography:

S 33. Thermal Analysis of Metals.

Study of thermal analysis of metals, including standard methods.

S 34. Study of Micro-Hardness.

A study of methods for obtaining "scratch" or "scoring" hardness, making use of a special instrument designed for this purpose.

S 35. X-Ray Metallography.

A study of the applications of the X-ray (1) in the location of cavities, cracks and other structural variations in metals (Metal Radiography) and (2) to determine the arrangement of atoms or molecules in crystals, size of grain in crystallin aggregates and the orientation of such crystallin material (X-ray Crystallography).

PROJECTS ADMINISTERED BY A.S.T.M. RESEARCH COMMITTEES

R 1. Effect of Arsenic and Tin upon High-Speed Tool Steels.

Substantially as stated by title. The special committee wishes to determine the effect of tin and arsenic in a martensitic structure such as occurs in hardened high-speed steel.

R 2. Yield Point of Structural Steel.

The committee has decided that it will consider (*a*) what is the significance to the engineer of the yield point when determined accurately; (*b*) what is the range in yield point of structural steel (that is, low-carbon, medium-carbon, silicon and nickel steels), due to a number of important factors, when furnished under specifications; (*c*) what testing procedure will insure sufficiently accurate determination of the yield point at minimum expense. The work under group (*c*) is to be taken up first.

PROJECTS ADMINISTERED BY JOINT COMMITTEES SPONSORED BY THE SOCIETY

J 1. Effect of Temperature upon the Properties of Metals. Joint committee of A.S.T.M. and A.S.M.E.

J 2. Effect of Phosphorus and Sulfur in Steel. Joint committee under the auspices of elevan organizations.

J 3. Concrete Culvert Pipe. Joint committee under the auspices of seven organizations.

J 4. Concrete and Reinforced Concrete. Joint committee under the auspices of five organizations.

In addition to the above research projects under the sole or joint auspices of the Society, the Society is represented upon the following projects under other auspices:

O 1. Molding Sand Research.

O 2. Research on Metal Springs.

O 3. Research on Rock Drill Steels.

O 4. Research on Gage Steel.

O 5. Highway Research.

O 6. Pattern Equipment Standardization.

O 7. Corrosion Committee, American Society of Refrigerating Engineers.

O 8. Corrosion Committee, National Research Council.

O 9. Welding.

The Society is also officially represented on the Division of Engineering and Industrial Research of the National Research Council.

PROGRESS REPORT OF RESEARCH COMMITTEE
ON
YIELD POINT OF STRUCTURAL STEEL

Since the formation of the Research Committee on Yield Point of Structural Steel, two meetings have been held, one in March, 1926, and the other in March, 1927. The committee has defined the scope of its problem, conducted the tests of Series No. 261 involving 300 tension and 90 compression specimens, and is now preparing a further program of tests to supplement the data obtained from Series No. 261.

The three fundamental parts of the problem before the committee are:

1. The significance to the engineer of the yield point when determined accurately;
2. The range in yield point of structural steel (that is, low-carbon, medium-carbon, silicon, and nickel steel) when furnished under specifications; and
3. The testing procedure which will insure sufficiently accurate determination of the yield point at minimum expense.

At its first meeting, after considering the fundamental parts of its problem, the committee decided to study the effect of speed in testing and method of determination upon the yield point of three important types of structural steel: (1) Carbon steel for bridges (A.S.T.M. Specifications A 7 – 24); (2) structural nickel steel (A.S.T.M. Specifications A 8 – 24); and (3) structural silicon steel (A.S.T.M. Specifications A 94 – 25 T).

Accordingly, a program of tests for Series No. 261 was prepared in which the procedure in selecting, marking, and testing specimens, and the method of reporting results was carefully stipulated.

The Illinois Steel Co. was responsible for the selection, preparation and donation of the specimens for these tests. Billets of the required grades of steel were rolled into $\frac{3}{4}$-in. round rods. These rods were cut into 16-ft. lengths and the 18-in. tension test specimens and 4-in. compression test specimens were cut from these bars in accordance with the outlined procedure.

The five laboratories which cooperated in these tests are: The Coatesville Laboratory of the Bethlehem Steel Co., the South Works and Gary Laboratories of the Illinois Steel Co., the Materials Laboratories at Rensselaer Polytechnic Institute and the University of Wisconsin.

At each laboratory 20 tension tests were made on each type of steel. These specimens were tested in four groups of five each, using the same speed of machine at yield point for a given group. The speeds used by the several laboratories differed somewhat but covered the range 0.05 to 2.0 in. per minute. At each college laboratory 15 compression tests were also made on each type of steel. In like manner, these were run in groups of five at different speeds. The range of speeds covered in the compression tests was 0.025 to 0.185 in. per minute.

For detecting the yield point the following four methods were used: (*a*) by drop of scale beam, (*b*) by the loosening of the oxide scale, (*c*) by multiplying dividers and (*d*) by strain gage. The first three methods were employed in all laboratories, the last method in the college laboratories only.

The testing machines were of Riehlé or Olsen types and varied in capacity from 60,000 to 200,000 lb. In all machines the movable head was operated by screws; the load was reduced by a system of levers articulating on knife edges and measured by a scale beam and poise.

The tests of Series No. 261 have given concordant and valuable information concerning the effect of speed on yield point of the steels tested. Using the methods of testing outlined in the program, cooperating laboratories secured closely checking values for the tensile strength, yield point, and ductility of these steels. The data have been compiled and sent to the members of the committee for study. Owing to the very uniform quality of the rod material furnished for these tests, it was thought desirable to withhold publication of these data until further tests have been made on specimens which more nearly represent the degree of variability inherent in commonly used structural shapes. Therefore, a second program of tests is now being outlined for the purpose of ascertaining the effect of speed of machine on the yield point of specimens cut from various portions of structural steel shapes.

This report has been submitted to letter ballot of the committee, which consists of 8 members, of whom 7 have voted affirmatively, none negatively, and 1 has refrained from voting.

Respectfully submitted on behalf of the committee,

M. O. Withey,
Chairman.

A.S.T.M.
TENTATIVE STANDARDS

SUBMITTED OR REVISED
AT THE
1927 ANNUAL MEETING

The term Tentative Standard is applied to a proposed Standard which is printed for one or more years with a view of eliciting criticism, of which the committee concerned will take due cognizance before recommending final action towards its adoption as standard.

Members of the Society and others are invited to direct written criticism of any of these Tentative Standards to the officer of the appropriate committee whose name and address appear in the footnote to the title of each Tentative Standard.

TENTATIVE SPECIFICATIONS
FOR
STRUCTURAL STEEL FOR LOCOMOTIVES AND CARS[1]

Serial Designation: A 113 - 27 T

This is a **Tentative Standard,** published for the purpose of eliciting criticism and suggestions, and as such is subject to annual revision.

ISSUED, 1927.

Scope.

1. These specifications apply to shapes, plates (except boiler and firebox plates) rivet steel and bars.

MANUFACTURE

Process.

2. The steel shall be made by the open-hearth process.

CHEMICAL PROPERTIES AND TESTS

Chemical Composition.

3. (*a*) The steel shall conform to the following requirements as to chemical composition:

		Structural Steel for Cars	Structural Steel for Locomotives	Plates for Cold Pressing	Rivet Steel
Phosphorus, per cent	Acid	not over 0.06	not over 0.06	not over 0.06	not over 0.04
	Basic	" " 0.04	" " 0.04	" " 0.04	" " 0.04
Sulfur, per cent		" " 0.06	" " 0.05	" " 0.06	" " 0.045

(*b*) When copper steel is specified, the following requirement as to copper shall govern:

Copper.................................not less than 0.20 per cent

Ladle Analyses.

4. An analysis of each melt of steel shall be made by the manufacturer to determine the percentages of carbon, manganese, phosphorus, and sulfur and also copper when copper steel is specified. This analysis shall be made from a test ingot taken during the pouring of the melt. The chemical composition thus determined shall be reported to the purchaser or his representative, and shall conform to the requirements specified in Section 3.

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[1] Criticisms of these Tentative Specifications are solicited and should be directed to Mr. G. H. Woodroffe, Secretary of Committee A-1 on Steel, Reading Iron Co., Reading, Pa.

Check Analyses.

5. Analyses may be made by the purchaser from finished material representing each melt. The phosphorus and sulfur content thus determined shall not exceed that specified in Section 3 by more than 25 per cent.

PHYSICAL PROPERTIES AND TESTS

Tension Tests.

6. (*a*) The material, except as specified in Paragraph (*c*), shall conform to the following requirements as to tensile properties:

Properties Considered	Structural Steel for Cars	Structural Steel for Locomotives	Plates for Cold Pressing	Rivet Steel
Tensile strength, lb. per sq. in.	50 000 - 65 000	55 000 - 65 000	48 000 - 58 000	45 000 - 60 000
Yield point, min., lb. per sq. in.	0.5 tens. str.	0.5 tens. str.	0.5 tens str.	0.5 tens. str.
Elongation in 8 in.,[a] min., per cent	$\frac{1\,500\,000}{\text{Tens. str.}}$	$\frac{1\,500\,000}{\text{Tens. str.}}$	$\frac{1\,500\,000}{\text{Tens. str.}}$	$\frac{1\,500\,000}{\text{Tens. str.}}$
Elongation in 2 in., min. per cent	22	22	..	..

[a] See Section 7.

(*b*) The yield point shall be determined by the drop of the beam of the testing machine.

(*c*) Plates $\frac{3}{16}$ in. and under in thickness, shapes less than 1 sq. in. in cross-section, flats $\frac{3}{16}$ in. and under in thickness, and other bars, except rivet rods, less than $\frac{1}{2}$ in. in thickness or diameter, need not be subjected to tension tests.

Modifications in Elongation.

7. (*a*) For material over $\frac{3}{4}$ in. in thickness, a deduction from the percentage of elongation in 8 in. specified in Section 6 (*a*) of 0.25 per cent shall be made for each increase of $\frac{1}{32}$ in. of the specified thickness above $\frac{3}{4}$ in., to a minimum of 18 per cent.

(*b*) For material under $\frac{5}{16}$ in. in thickness, a deduction from the percentage of elongation in 8 in. specified in Section 6 (*a*) of 1.25 per cent shall be made for each decrease of $\frac{1}{32}$ in. of the specified thickness below $\frac{5}{16}$ in.

Bend Tests.

8. (*a*) Bend test specimens for structural steel shall stand being bent cold through 180 deg. without cracking on the outside of the bent portion as follows: For material $\frac{3}{4}$ in. or under in thickness, flat on itself; for material over $\frac{3}{4}$ in. to and including $1\frac{1}{4}$ in. in thickness, around a pin the diameter of which is equal to the thickness of the specimen; and for material over $1\frac{1}{4}$ in. in thickness, around a pin the diameter of which is equal to twice the thickness of the specimen.

(*b*) Bend test specimens for rivet steel and plates for cold pressing shall stand being bent cold through 180 deg. flat on themselves without cracking on the outside of the bent portion.

Test Specimens.

9. (*a*) Test specimens shall be prepared for testing from the material in its rolled condition, except as specified in Paragraph (*b*).

(*b*) Test specimens for rivet bars which have been cold-drawn shall be normalized before testing.

(*c*) Test specimens shall be taken longitudinally and, except as specified in Paragraphs (*e*) and (*f*), shall be of the full thickness or section of material as rolled.

(*d*) Test specimens for plates, shapes, and flats may be machined to the form and dimensions shown in Fig. 1, or with both edges parallel.

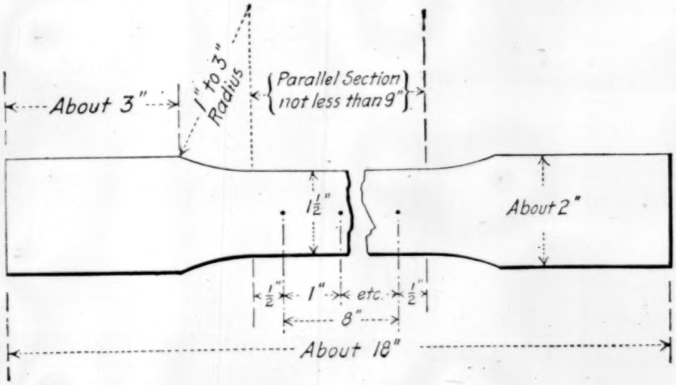
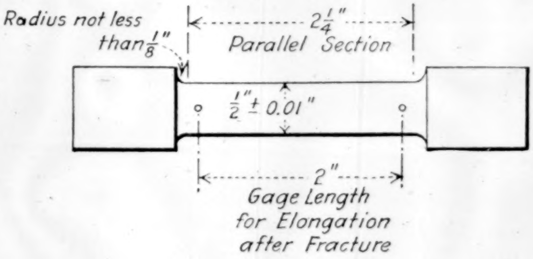

About 3"
1" to 3" Radius
Parallel Section not less than 9"
1½"
About 2"
½"
1"
etc.
½"
8"
About 18"

FIG. 1.


Radius not less than ⅛"
2¼"
Parallel Section
½" ± 0.01"
2"
Gage Length for Elongation after Fracture

Note:- The Gage Length, Parallel Section, and Fillets shall be as Shown, but the Ends may be of any Shape to fit the Holders of the Testing Machine in such a Way that the Load shall be axial.

FIG. 2.

(*e*) Tension test specimens for material over 1½ in. in thickness or diameter may be machined to a thickness or diameter of at least ¾ in. for a length of at least 9 in., or they may conform to the dimensions shown in Fig. 2.

(*f*) Bend test specimens for material over 1½ in. in thickness or diameter may be machined to a thickness or diameter of at least ¾ in. or to 1 by ½ in. in section.

(*g*) The machined sides of rectangular bend test specimens may have the corners rounded to a radius of not over $\frac{1}{16}$ in.

Number of Tests.

10. (*a*) One tension and one bend test shall be made from each melt: except that if material from one melt differs ⅜ in. or more in

thickness, one tension and one bend test shall be made from both the thickest and the thinnest material rolled.

(*b*) If any test specimen shows defective machining or develops flaws, it may be discarded and another specimen substituted.

(*c*) If the percentage of elongation of any tension test specimen is less than that specified in Section 6 (*a*) and any part of the fracture is more than $\frac{3}{4}$ in. from the center of the gage length of a 2-in. specimen or is outside the middle third of the gage length of an 8-in. specimen, as indicated by scribe scratches marked on the specimen before testing, a retest shall be allowed.

TABLE I.—PERMISSIBLE VARIATIONS OF RECTANGULAR PLATES ORDERED TO WEIGHT.

Ordered Weight, lb. per sq. ft.	Permissible Variations in Average Weights per Square Foot of Plates for Widths Given, Expressed in Percentages of Ordered Weights.																		Ordered Weight, lb. per sq. ft.
	Under 48 in.		48 to 60 in., excl.		60 to 72 in., excl.		72 to 84 in., excl.		84 to 96 in., excl.		96 to 108in., excl.		108 to 120in., excl.		120 to 132in., excl.		132 in. or over		
	Over	Under	Over	Under	Over	Under	Over	Under	Over	Under	Over	Under	Over	Under	Over	Under	Over	Under	
Under 5............	5	3	5.5	3	6	3	7	3	...	...	...	...	...	...	...	...	...	...	Under 5
5 to 7.5 exclusive.	4.5	3	5	3	5.5	3	6	3	...	...	...	...	...	...	...	...	...	...	5 to 7.5 exclusive
7.5 to 10 exclusive.	4	3	4.5	3	5	3	5.5	3	6	3	7	3	8	3	...	...	...	...	7.5 to 10 exclusive
10 to 12.5 exclusive.	3.5	2.5	4	3	4.5	3	5	3	5.5	3	6	3	7	3	8	3	9	3	10 to 12.5 exclusive
12.5 to 15 exclusive.	3	2.5	3.5	2.5	4	3	4.5	3	5	3	5.5	3	6	3	7	3	8	3	12.5 to 15 exclusive
15 to 17.5 exclusive.	2.5	2.5	3	2.5	3.5	2.5	4	3	4.5	3	5	3	5.5	3	6	3	7	3	15 to 17.5 exclusive
17.5 to 20 exclusive.	2.5	2	2.5	2.5	3	2.5	3.5	2.5	4	3	4.5	3	5	3	5.5	3	6	3	17.5 to 20 exclusive
20 to 25 exclusive.	2	2	2.5	2	2.5	2.5	3	2.5	3.5	2.5	4	3	4.5	3	5	3	5.5	3	20 to 25 exclusive
25 to 30 exclusive.	2	2	2	2	2.5	2	2.5	2.5	3	2.5	3.5	3	4	3	4.5	3	5	3	25 to 30 exclusive
30 to 40 exclusive.	2	2	2	2	2	2	2.5	2	2.5	2.5	3	2.5	3.5	3	4	3	4.5	3	30 to 40 exclusive
40 or over..........	2	2	2	2	2	2	2	2	2.5	2	2.5	2.5	3	2.5	3.5	3	4	3	40 or over

NOTE.—The weight per square foot of individual plates shall not vary from the ordered weight by more than $1\frac{1}{3}$ times the amount given in this table.

PERMISSIBLE VARIATIONS IN WEIGHT AND DIMENSIONS

Permissible Variations.

11. (*a*) One cubic inch of rolled steel is assumed to weigh 0.2833 lb. The cross-sectional area or weight of each structural-size shape and of each universal mill plate up to and including 36 in. in width shall not vary more than 2.5 per cent from the theoretical or specified amounts. The thickness or weight of rectangular sheared mill plates and of rectangular universal mill plates over 36 in. in width shall conform to the requirements of Paragraphs (*b*) and (*c*); the cross-sectional area or weight of bar size[1] angles, tees, zees, and channels shall conform to the requirements of Paragraph (*d*); and the cross-sectional dimensions of bars shall conform to the requirements of Paragraph (*e*).

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[1] A channel is in "bar" size when its greatest dimension is less than 3 in. An angle, tee or zee is in "bar" size when its greatest dimension is less than 3 in., or when it is 3 in. or more and at the same time the thickness is less than $\frac{1}{4}$ in.

(*b*) *When Ordered to Weight per Square Foot:* The weight of each lot[1] of plates in each shipment shall not vary from the weight ordered more than the amounts given in Table I.

(*c*) *When Ordered to Thickness:* The thickness of each plate shall not vary more than 0.01 in. under that ordered.

TABLE II.—PERMISSIBLE OVERWEIGHTS OF RECTANGULAR PLATES ORDERED TO THICKNESS.

Ordered Thickness, in.	Permissible Excess in Average Weights per Square Foot of Plates for Widths Given, Expressed in Percentages of Nominal Weights.									Ordered Thickness, in.
	Under 48 in.	48 to 60 in., excl.	60 to 72 in., excl.	72 to 84 in., excl.	84 to 96 in., excl.	96 to 108 in., excl.	108 to 120 in., excl.	120 to 132 in., excl.	132 in. or over	
Under $\frac{1}{8}$..........	9	10	12	14	....	....	....	....	....	Under $\frac{1}{8}$
$\frac{1}{8}$ to $\frac{3}{16}$ exclusive	8	9	10	12	....	....	....	....	....	$\frac{1}{8}$ to $\frac{3}{16}$ exclusive
$\frac{3}{16}$ to $\frac{1}{4}$ exclusive	7	8	9	10	12	....	....	....	....	$\frac{3}{16}$ to $\frac{1}{4}$ exclusive
$\frac{1}{4}$ to $\frac{5}{16}$ exclusive	6	7	8	9	10	12	14	16	19	$\frac{1}{4}$ to $\frac{5}{16}$ exclusive
$\frac{5}{16}$ to $\frac{3}{8}$ exclusive	5	6	7	8	9	10	12	14	17	$\frac{5}{16}$ to $\frac{3}{8}$ exclusive
$\frac{3}{8}$ to $\frac{7}{16}$ exclusive	4.5	5	6	7	8	9	10	12	15	$\frac{3}{8}$ to $\frac{7}{16}$ exclusive
$\frac{7}{6}$ to $\frac{1}{2}$ exclusive	4	4.5	5	6	7	8	9	10	13	$\frac{7}{16}$ to $\frac{1}{2}$ exclusive
$\frac{1}{2}$ to $\frac{5}{8}$ exclusive	3.5	4	4.5	5	6	7	8	9	11	$\frac{1}{2}$ to $\frac{5}{8}$ exclusive
$\frac{5}{8}$ to $\frac{3}{4}$ exclusive	3	3.5	4	4.5	5	6	7	8	9	$\frac{5}{8}$ to $\frac{3}{4}$ exclusive
$\frac{3}{4}$ to 1 exclusive	2.5	3	3.5	4	4.5	5	6	7	8	$\frac{3}{4}$ to 1 exclusive
1 or over..........	2.5	2.5	3	3.5	4	4.5	5	6	7	1 or over

TABLE III.—PERMISSIBLE VARIATIONS IN WEIGHT OF BAR SIZES OF ANGLES, TEES, ZEES, AND CHANNELS.

Dimensions, in.	Thickness, in.	Variations, expressed in percentages of Nominal Weights
Any dimension over $1\frac{1}{2}$....................................	Over $\frac{3}{16}$	4 over and under
All dimensions $1\frac{1}{2}$ and less....................................	Over $\frac{3}{16}$	5 " " "
Any dimension over $1\frac{1}{2}$....................................	$\frac{3}{16}$ and less	6 " " "
All dimensions $1\frac{1}{2}$ and less....................................	$\frac{3}{16}$ and less	7 " " "

The overweight in each lot[1] of plates in each shipment shall not exceed the amount given in Table II.

(*d*) The weight of each lot[2] of bar sizes of angles, tees, zees, and channels in each shipment shall not vary from the weight ordered more than the amounts given in Table III.

(*e*) The cross-sectional dimension of bars shall not vary from the size ordered more than the amounts given in Tables IV and V.

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[1] The term "lot" as applied to Table I means all the plates of each group width and group weight. As applied to Table II, it means all the plates of each group width and group thickness.

[2] The term "lot" here means all of the bars of each group dimension and group thickness shown in Table III.

12. Except in cases of special agreement between the purchaser and manufacturer that the material shall be furnished recut to exact ordered dimensions, the length of all shapes, plates, and bars shall not vary under the dimensions ordered more than $\frac{1}{4}$ in. The width of plates shall not vary under the dimensions ordered more than $\frac{1}{4}$ in. for sheared mill plates nor more than $\frac{1}{8}$ in. for universal mill plates. The variation over the dimension ordered shall not be more than is consistent with thickness, length, and good mill practice.

TABLE IV.—PERMISSIBLE VARIATIONS IN CROSS-SECTIONAL DIMENSIONS OF ROUNDS, SQUARES AND HEXAGONS.

Dimensions, in.	Variations, in.	
	Over	Under
Up to and including $\frac{1}{2}$	0.007	0.007
Over $\frac{1}{2}$ up to and including 1	0.010	0.010
Over 1 " " " " 2	$\frac{1}{32}$	$\frac{1}{64}$
Over 2 " " " " 3	$\frac{3}{64}$	$\frac{1}{32}$
Over 3 " " " " 5	$\frac{3}{32}$	$\frac{1}{32}$
Over 5 " " " " 8	$\frac{1}{8}$	$\frac{1}{16}$

TABLE V.—PERMISSIBLE VARIATIONS IN CROSS-SECTIONAL DIMENSION OF FLATS.

Dimensions, in.	Variations in Width, in.		Variations in Thickness, Over and Under, from Thickness Specified, in.			
	Over	Under	$\frac{3}{16}$ in. and Under	Over $\frac{3}{16}$ in. up to $\frac{1}{2}$ in., inclusive	Over $\frac{1}{2}$ in. up to 1 in., inclusive	Over 1 in. up to 2 in., inclusive
Up to and including 1	$\frac{1}{32}$	$\frac{1}{64}$	0.006	0.008	0.010	..
Over 1 up to and including 2	$\frac{3}{64}$	$\frac{1}{32}$	0.008	0.012	0.015	$\frac{1}{32}$
Over 2 " " " " 4	$\frac{1}{16}$	$\frac{3}{64}$	0.010	0.015	0.020	$\frac{1}{32}$
Over 4 " " " " 6	$\frac{3}{32}$	$\frac{1}{16}$	0.010	0.015	0.020	$\frac{1}{32}$

FINISH

Finish. 13. The finished material shall be free from injurious defects and have a workmanlike finish.

MARKING

Marking. 14. The name or brand of the manufacturer and the melt number shall be legibly rolled or stamped on all finished material, except that rivet bars and other small sections shall, when loaded for shipment, be properly separated and marked for identification. The melt number shall be legibly marked, by stamping if practicable, on each test specimen.

INSPECTION AND REJECTION

Inspection. 15. The inspector representing the purchaser shall have free entry, at all times while work on the contract of the purchaser is being performed, to all parts of the manufacturer's works which concern the manufacture of the material ordered. The manufacturer shall afford the inspector, without charge, all reasonable facilities to satisfy him that the material is being furnished in accordance with these specifications.

All tests (except check analyses) and inspection shall be made at the place of manufacture prior to shipment, unless otherwise specified, and shall be so conducted as not to interfere unnecessarily with the operation of the works.

Rejection. 16. (*a*) Unless otherwise specified, any rejection based on tests made in accordance with Section 5 shall be reported within five working days from the receipt of samples.

(*b*) Material which shows injurious defects subsequent to its acceptance at the manufacturer's works will be rejected, and the manufacturer shall be notified.

Rehearing. 17. Samples tested in accordance with Section 5, which represent rejected material, shall be preserved for two weeks from the date of the test report. In case of dissatisfaction with the results of the tests, the manufacturer may make claim for a rehearing within that time.

TENTATIVE SPECIFICATIONS
FOR
MARINE BOILER STEEL PLATES[1]

Serial Designation: A 114 - 27 T

This is a **Tentative Standard,** published for the purpose of eliciting criticism and suggestions, and as such is subject to annual revision.

Issued, 1927.

Scope. 1. These specifications cover two grades of steel for marine boilers, namely: Grade A and Grade B.

MANUFACTURE

Process. 2. The steel shall be made by the open-hearth process.

CHEMICAL PROPERTIES AND TESTS

Chemical Composition. 3. The steel shall conform to the following requirements as to chemical composition:

Phosphorus	Acid	not over 0.04 per cent
	Basic	" " 0.035 " "
Sulfur		" " 0.04 " "

Ladle Analyses. 4. An analysis of each melt of steel shall be made by the manufacturer to determine the percentages of carbon, manganese, phosphorus, and sulfur. This analysis shall be made from a test ingot taken during the pouring of the melt. The chemical composition thus determined shall be reported to the purchaser or his representative and shall conform to the requirements specified in Section 3.

Check Analyses. 5. An analysis may be made by the purchaser from the tension test specimen representing the bottom of each plate as rolled. The chemical composition thus determined shall conform to the requirements specified in Section 3.

PHYSICAL PROPERTIES AND TESTS

Tension Tests. 6. (*a*) The material shall conform to the following requirements as to tensile properties:

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[1] Criticisms of these Tentative Specifications are solicited and should be directed to Mr. G. H. Woodroffe, Secretary of Committee A-1 on Steel, Reading Iron Co., Reading, Pa.

	GRADE A	GRADE B
Tensile strength, lb. per sq. in....	60 000 - 70 000	55 000 - 65 000
Yield point, min., lb. per sq. in....	0.5 tens. str.	0.5 tens. str.
Elongation in 8 in., min., per cent.	$\frac{1\,500\,000}{\text{tens. str.}}$	$\frac{1\,550\,000}{\text{tens. str.}}$

(*b*) The yield point shall be determined by the drop of the beam of the testing machine.

Modification in Elongation.

7. For material over $\frac{3}{4}$ in. in thickness, a deduction from the percentages of elongation specified in Section 6 (*a*) of 0.125 per cent shall be made for each increase of $\frac{1}{32}$ in. of the specified thickness above $\frac{3}{4}$ in. to a minimum of 20 per cent for Grade A steel and 22 per cent for Grade B steel.

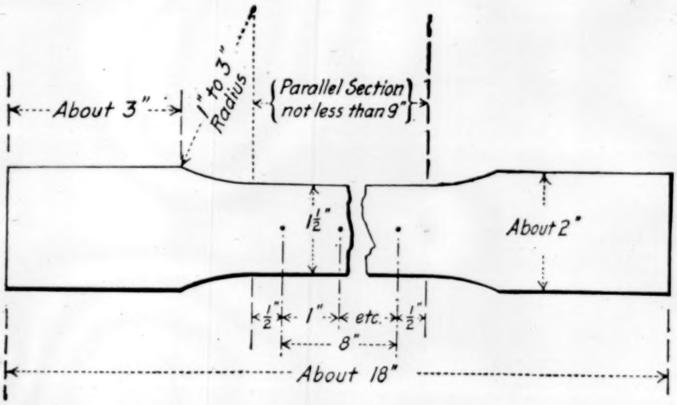

FIG. 1.

Bend Tests.

8. (*a*) The test specimen for Grade A steel shall stand being bent cold through 180 deg. without cracking on the outside of the bent portion, as follows: For material 1 in. or under in thickness, around a pin the diameter of which is equal to 1½ times the thickness of the specimen; for material over 1 in. to and including 1½ in. in thickness, around a pin the diameter of which is equal to three times the thickness of the specimen; and for material over 1½ in. in thickness, around a pin the diameter of which is equal to four times the thickness of the specimen.

(*b*) The test specimen for Grade B steel shall stand being bent cold through 180 deg. without cracking on the outside of the bent portion, as follows: For material 1 in. or under in thickness, around a pin the diameter of which is equal to the thickness of the specimen; for material over 1 in. to and including 1½ in. in thickness, around a pin the diameter of which is equal to twice the thickness of the specimen; and for material over 1½ in. in thickness, around a pin the diameter of which is equal to three times the thickness of the specimen.

Test Specimens. 9. (*a*) The tension test specimens shall be taken longitudinally from the finished rolled material. In the case of plates rolled from ingots, these specimens shall be taken in the direction of the longitudinal axis of the ingot; one from the top and one from the bottom on the same side of the plates as rolled. In the case of plates rolled from slabs, the tension test specimens shall be taken from diagonal corners.

In the case of plates rolled from ingots, the bend test specimen shall be taken from the middle of the top of the finished rolled material at right angles to the longitudinal axis of the ingot. In the case of plates rolled from slabs, it shall be taken from the middle of one end at right angles to the longitudinal axis of the plate as rolled.

TABLE I.—PERMISSIBLE OVERWEIGHTS OF RECTANGULAR PLATES ORDERED TO THICKNESS.

Ordered Thickness, in.	Permissible Excess in Average Weights per Square Foot of Plates for Widths Given, Expressed in Percentages of Nominal Weights.									Ordered Thickness, in.
	Under 48 in.	48 to 60 in., excl.	60 to 72 in., excl.	72 to 84 in., excl.	84 to 96 in., excl.	96 to 108 in., excl.	108 to 120 in., excl.	120 to 132 in., excl.	132 in. or over.	
Under $\frac{1}{8}$	9	10	12	14	..	..	..	..	..	Under $\frac{1}{8}$
$\frac{1}{8}$ to $\frac{3}{16}$ excl.	8	9	10	12	..	..	..	..	..	$\frac{1}{8}$ to $\frac{3}{16}$ excl.
$\frac{3}{16}$ to $\frac{1}{4}$ excl.	7	8	9	10	12	..	..	..	..	$\frac{3}{16}$ to $\frac{1}{4}$ excl.
$\frac{1}{4}$ to $\frac{5}{16}$ excl.	6	7	8	9	10	12	14	16	19	$\frac{1}{4}$ to $\frac{5}{16}$ excl.
$\frac{5}{16}$ to $\frac{3}{8}$ excl.	5	6	7	8	9	10	12	14	17	$\frac{5}{16}$ to $\frac{3}{8}$ excl.
$\frac{3}{8}$ to $\frac{7}{16}$ excl.	4.5	5	6	7	8	9	10	12	15	$\frac{3}{8}$ to $\frac{7}{16}$ excl.
$\frac{7}{16}$ to $\frac{1}{2}$ excl.	4	4.5	5	6	7	8	9	10	13	$\frac{7}{16}$ to $\frac{1}{2}$ excl.
$\frac{1}{2}$ to $\frac{5}{8}$ excl.	3.5	4	4.5	5	6	7	8	9	11	$\frac{1}{2}$ to $\frac{5}{8}$ excl.
$\frac{5}{8}$ to $\frac{3}{4}$ excl.	3	3.5	4	4.5	5	6	7	8	9	$\frac{5}{8}$ to $\frac{3}{4}$ excl.
$\frac{3}{4}$ to 1 excl.	2.5	3	3.5	4	4.5	5	6	7	8	$\frac{3}{4}$ to 1 excl.
1 or over	2.5	2.5	3	3.5	4	4.5	5	6	7	1 or over

(*b*) Tension and bend test specimens shall be of the full thickness of the material as rolled, and shall be machined to the form and dimensions shown in Fig. 1; except that bend test specimens may be machined with both edges parallel.

(*c*) The machined sides of rectangular bend test specimens may have the corners rounded to a radius not over $\frac{1}{16}$ in.

Number of Tests. 10. (*a*) Two tension tests and one bend test shall be made from each plate as rolled.

(*b*) If any test specimen shows defective machining or develops flaws, it may be discarded and another specimen substituted.

(*c*) If the percentage of elongation of any tension test specimen is less than that specified in Section 6 (*a*) and any part of the fracture is outside the middle third of the gage length, as indicated by scribe scratches marked on the specimen before testing, a retest shall be allowed.

PERMISSIBLE VARIATIONS IN WEIGHT AND THICKNESS

Permissible Variations.

11. The thickness of each plate shall not vary more than 0.01 in. under that ordered. The overweight of each "lot[1] in each shipment" shall not exceed the amount given in Table I. One cubic inch of rolled steel is assumed to weigh 0.2833 lb.

FINISH

Finish.

12. The finished material shall be free from injurious defects and shall have a workmanlike finish.

MARKING

Marking.

13. (*a*) The name or brand of the manufacturer, the manufacturer's test identification number, Marine "A" or "B," and lowest tensile strength specified shall be legibly stamped on each finished plate in two places about 18 in. from the edges and on each butt strap near the center line about 18 in. from one end. The manufacturer's test identification number shall be legibly stamped on each test specimen.

(*b*) When required, the monogram stamp of the classification societies and the Department of Commerce shall be placed on each plate adjacent to the stamping specified in Paragraph (*a*).

INSPECTION AND REJECTION

Inspection.

14. The inspector representing the purchaser shall have free entry, at all times while work on the contract of the purchaser is being performed, to all parts of the manufacturer's works which concern the manufacture of the material ordered. The manufacturer shall afford the inspector, without charge, all reasonable facilities to satisfy him that the material is being furnished in accordance with these specifications. All tests (except check analyses) and inspection shall be made at the place of manufacture prior to shipment, unless otherwise specified, and shall be so conducted as not to interfere unnecessarily with the operation of the works.

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[1] The term lot means all of the plates of each group width and group thickness.

Rejection. 15. (*a*) Unless otherwise specified, any rejection based on tests made in accordance with Section 5 shall be reported within five working days from the receipt of samples.

(*b*) Material which shows injurious defects subsequent to its acceptance at the manufacturer's works will be rejected, and the manufacturer shall be notified.

Rehearing. 16. Samples tested in accordance with Section 5, which represent rejected material, shall be preserved for two weeks from the date of the test report. In case of dissatisfaction with the results of the tests, the manufacturer may make claim for a rehearing within that time.

TENTATIVE SPECIFICATIONS
FOR
FORGED OR ROLLED STEEL PIPE FLANGES FOR HIGH-TEMPERATURE SERVICE[1]

Serial Designation: A 105 – 27 T

This is a **Tentative Standard,** published for the purpose of eliciting criticism and suggestions, and as such is subject to annual revision.

ISSUED, 1926; REVISED, 1927.

Scope. 1. (*a*) These specifications cover forged or rolled steel flanges to be attached to piping for high temperature service (Note 1).

(*b*) Three classes of material are covered, designated Class A, B and C respectively. Class A is intended for forge welding and is classified by the chemical properties as specified in Section 6 (*a*) and (*b*) and by the physical properties as specified in Section 9 (*a*). Classes B and C are classified in accordance with their physical properties as specified in Section 9 (*a*).

Certification of Test. 2. Unless otherwise specified on the order, a certification that the material conforms to the requirements of these specifications shall be the basis of acceptance of the material.

MANUFACTURE

Process 3. The steel may be made by either or both of the following processes: Open-hearth or electric furnace.

Discard. 4. A sufficient discard shall be made from each ingot to secure freedom from injurious piping and undue segregation.

Heat Treatment. 5. (*a*) Class A steel does not require heat treatment (Note 2).

(*b*) Classes B and C steels shall be heat treated. Heat treatment may consist of annealing or normalizing.

Annealing. (*c*) The procedure for annealing shall consist in allowing the flanges, immediately after forging or rolling, to cool to a temperature below the critical range, under suitable conditions to prevent injuries by too rapid cooling. They shall then be uniformly reheated to the proper temperature to refine the grain (a group thus reheated being known as an "annealing charge") and allowed to cool uniformly in the furnace.

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[1] Criticisms of these Tentative Specifications are solicited and should be directed to Mr. G. H. Woodroffe, Secretary of Committee A-1 on Steel, Reading Iron Co., Reading, Pa.

Normalizing. (*d*) The procedure for normalizing shall consist in allowing the flanges, immediately after forging or rolling, to cool to a temperature below the critical range, under suitable conditions to prevent injuries by too rapid cooling. They shall then be uniformly reheated to the proper temperature to refine the grain (a group thus reheated being known as a "normalizing charge") and allowed to cool in still air.

(*e*) No flanges which have been quenched in any liquid medium shall be offered under these specifications.

CHEMICAL PROPERTIES AND TESTS

Chemical Composition. 6. (*a*) The steel shall conform to the following requirements as to chemical composition:

	CLASS A	CLASSES B AND C
Manganese, per cent	0.35 – 0.60	0.40 – 0.80
Phosphorus, per cent	not over 0.05	not over 0.05
Sulfur, per cent	not over 0.05	not over 0.05
Silicon, per cent	not over 0.40	....

(*b*) The carbon content of Class A material shall not exceed 0.20 per cent. The carbon content of Class B and C material shall be a matter of agreement between the purchaser and the manufacturer.

Ladle Analysis. 7. An analysis of each melt of steel shall be made by the manufacturer to determine the percentage of the elements specified in Section 6.

Check Analysis. 8. (*a*) An analysis may be made by the purchaser from one forged or rolled flange representing each melt. The chemical composition thus determined shall conform to the requirements specified in Section 6, except that phosphorus and sulfur may not exceed 0.055 per cent.

(*b*) All drillings for analysis shall be taken at least $\frac{1}{4}$ in. below the surface, or turnings may be taken from test specimens.

PHYSICAL PROPERTIES AND TESTS

Tension Tests. 9. (*a*) Forged or rolled steel flanges shall conform to the following minimum requirements as to tensile properties:

	FLANGES FOR FORGE WELDING	FLANGES NOT FOR FORGE WELDING	
	CLASS A	CLASS B	CLASS C
Tensile strength, lb. per sq. in.	54 000	60 000	70 000
Yield point, lb. per sq. in.	30 000	30 000	36 000
Elongation in 2 in., per cent	25.0	25.0	22.0
Reduction of area, per cent	38.0	38.0	30.0

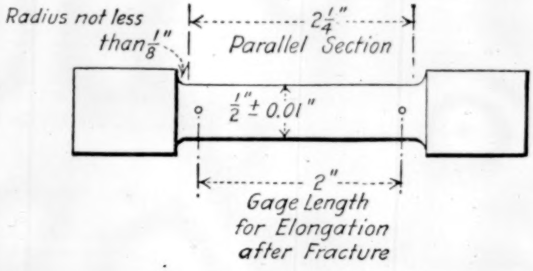
(*b*) The yield point shall be determined by the drop of the beam of the testing machine, or by dividers, at a speed of head of the testing machine not to exceed $\frac{1}{8}$ in. per minute. The tensile strength shall be determined at a speed of head not to exceed $1\frac{1}{2}$ in. per minute.

Number of Tests. 10. (*a*) One tension test shall be made from each melt or for each annealing or normalizing charge. If more than one melt is represented in any annealing or normalizing charge, a test shall be made from each melt.

(*b*) If any test specimen shows defective machining or develops flaws, it may be discarded and another specimen substituted.

(*c*) If the percentage of elongation of any test specimen is less than that specified in Section 9 (*a*) and any part of the fracture is more than $\frac{3}{4}$ in. from the center of the gage length, as indicated by scribe scratches marked on the specimen before testing, a re-test shall be allowed.

(*d*) For purposes of testing, the necessary extra flanges shall be provided to furnish the specimens required in Paragraph (*a*). The test specimen shall be cut tangentially from the flange portion approximately midway between the inner and outer surfaces and approximately midway between the front and back faces.


Radius not less than $\frac{1}{8}$"
$2\frac{1}{4}$"
Parallel Section
$\frac{1}{2}$" ± 0.01"
2"
Gage Length for Elongation after Fracture

Note:- The Gage Length, Parallel Section, and Fillets shall be as Shown, but the Ends may be of any Shape to fit the Holders of the Testing Machine in such a Way that the Load shall be axial.

FIG. 1

Tension Test Specimens. 11. (*a*) The tension test specimens taken from the flanges shall conform to the dimensions shown in Fig. 1, except as specified in Paragraph (*b*). The ends shall be of a form to fit the holders of the testing maching in such a way that the load shall be axial.

(*b*) In the case of small sections which will not permit of taking the standard test specimen specified in Paragraph (*a*), the tension test specimen shall be as large as feasible and its dimensions shall be proportional to those shown in Fig. 1. The gage length for measuring elongation shall be four times the diameter of the specimen.[1]

Retests. 12. If any of the results of the physical tests of any test lot do not conform to the requirements specified, the manufacturer may re-treat such lots one or more times and retests shall be made as specified in Section 10 (*a*).

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[1] These requirements are in accordance with the provisions of Section 8 of the Tentative Methods of Tension Testing of Metallic Materials (Serial Designation: E 8 - 27 T), see p. 1067.

WORKMANSHIP AND FINISH

Workmanship. 13. (*a*) The flanges shall conform to the sizes and shapes specified by the purchaser.

(*b*) The flanges shall be free from injurious defects and shall have a workmanlike finish.

MARKING

Identification. 14. Identification marks shall be stamped legibly on each flange.

INSPECTION AND REJECTION

Inspection. 15. (*a*) The inspector representing the purchaser shall have free entry, at all times while work on the contract of the purchaser is being performed, to all parts of the manufacturer's works which concern the manufacture of the flanges ordered. The manufacturer shall afford the inspector, without charge, all reasonable facilities to satisfy him that the flanges are being furnished in accordance with these specifications. All tests (except check analyses) and inspection shall be made at the place of manufacture prior to shipment and shall be so conducted as not to interfere unnecessarily with the operation of the works.

Rejection. 16. (*a*) Unless otherwise specified, any rejection based on tests shall be reported within twelve working days from the receipt of samples.

(*b*) Flanges which show injurious defects while being finished shall be rejected.

Rehearing. 17. Samples tested in accordance with Section 8, which represent rejected flanges, shall be preserved for two weeks from the date of the test report. In case of dissatisfaction with the results of the tests, the manufacturer may make claim for a rehearing within that time.

EXPLANATORY NOTES

NOTE 1.—This contemplates temperatures up to 750° F. (400° C.), or at the discretion of the designing engineer, higher temperatures with appropriate pressures may be used. Reference may be made to the dimensional standards for pressures and temperatures formulated by the Sectional Committee on Standardization of Pipe Flanges and Fittings, under the sponsorship of the Heating and Piping Contractors National Association, Manufacturers Standardization Society of the Valve and Fittings Industry, and The American Society of Mechanical Engineers, and organized under the procedure of the American Engineering Standards Committee.

NOTE 2.—It is recommended that Class A flanges and pipe be annealed or normalized following the forge welding operation.

TENTATIVE SPECIFICATIONS
FOR
LAP-WELDED AND SEAMLESS STEEL PIPE FOR HIGH-TEMPERATURE SERVICE[1]

Serial Designation: A 106 – 27 T

This is a **Tentative Standard,** published for the purpose of eliciting criticism and suggestions, and as such is subject to annual revision.

ISSUED, 1926; REVISED, 1927.

Scope.

1. These specifications cover lap-welded and seamless steel pipe for 250, 400, 600, 900 and 1350 lb. per sq. in. pressure and high temperatures (Note 1). Pipe ordered under these specifications shall be suitable for bending, flanging and similar forming operations (Note 2).

MANUFACTURE

Process.

2. (*a*) The steel for lap-welded pipe shall be of soft weldable quality made by the open-hearth process. The steel for seamless pipe may be made by either or both of the following processes: open-hearth or electric-furnace.

(*b*) All welded pipe shall be given a double welding operation.

(*c*) Welded pipe 2 in. or over in nominal diameter shall be made by the lap-weld process. All pipe $1\frac{1}{2}$ in. or under in nominal diameter shall be made by the seamless process.

(*d*) Unless otherwise specified, seamless pipe shall be furnished hot finished. Upon agreement, cold drawn and annealed pipe may be furnished.

CHEMICAL PROPERTIES AND TESTS

Chemical Composition.

3. (*a*) The steel for welded and seamless pipe shall conform to the following ladle requirements as to chemical composition:

	WELDED	SEAMLESS
Phosphorus, per cent	not over 0.06 (Note 3)	not over 0.04
Sulfur, per cent	" " 0.05	" " 0.05

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[1] Criticisms of these Tentative Specifications are solicited and should be directed to Mr. G. H. Woodroffe, Secretary of Committee A-1 on Steel, Reading Iron Co., Reading, Pa.

Check Analysis. (*b*) Analysis may be made by the purchaser from each lot of 500 lengths or less of finished pipe. The phosphorus and sulfur content thus determined shall not exceed that specified in Section 3(*a*) by more than 25 per cent. Drillings for analysis shall be taken from several points around each pipe.

PHYSICAL PROPERTIES AND TESTS

Tension Tests. 4. (*a*) The material shall conform to the following minimum requirements as to tensile properties:

		Seamless	
	Welded	Low Carbon	Medium Carbon
Tensile strength, lb. per sq. in....	45 000	48 000	62 000
Yield point, lb. per sq. in........	25 000	26 500	35 000
Elongation in 2 in., per cent.....	30	40	25

(*b*) The yield point shall be determined by the drop of the beam of the testing machine, or by other approved methods.

Hydrostatic Tests. 5. Unless otherwise agreed, each length of pipe ordered under these specifications shall be tested at the mill to the hydrostatic test pressures specified in the table below. Welded pipe shall be struck near both ends while under pressure, with a 2-lb. hammer or equivalent.

Class of Pipe, Working Pressure, lb. per sq. in.	Standard Test Pressure. lb. per sq. in.
250	750
400	1000
600	1500
900	2000
1350	3000

Flattening Tests. 6. (*a*) For welded pipe, a section of pipe 6 in. long shall be flattened between parallel plates until the distance between the plates is one-third the outside diameter of the pipe, with the weld located 90 deg. from the line of direction of the applied force, without developing cracks.

(*b*) For low-carbon seamless pipe over 2 in. in nominal diameter, a section of pipe not less than 2½ in. long shall be flattened between parallel plates until the distance between the plates is one-third the outside diameter of the pipe, without developing cracks. In no case shall the distance between the plates be less than five times the thickness of the pipe wall.

(*c*) For medium-carbon seamless pipe over 2 in. in nominal diameter, a section of pipe not less than 2½ in. long shall be flattened between parallel plates until the distance between the plates is one-half the outside diameter of the pipe, without developing cracks.

In no case shall the distance between the plates be less than seven times the thickness of the pipe wall.

Bend Tests

7. For seamless pipe 2 in. in nominal diameter and smaller, a sufficient length of pipe shall stand being bent cold through 90 deg. around a cylindrical mandrel, the diameter of which is twelve times the nominal diameter of the pipe, without developing cracks. When ordered for close coiling, the bend test shall be made 180 deg. around a mandrel which is eight times the diameter of the pipe, without failure.

TABLE I.—DIMENSIONS AND WEIGHTS OF PIPE FOR 250, 400, 600, 900 AND 1350-LB.-PER-SQ.-IN. STANDARDS FOR HIGH TEMPERATURES.

Nominal Pipe Size, in.	Outside Diameter, in.	Threads per in.	250 lb.		400 lb.		400 lb.		600 lb.		900 lb.		1350 lb.	
			Wall Thickness, in.	Weight per Lineal Foot, Plain Ends, lb.	Wall Thickness, in.	Weight per Lineal Foot, Plain Ends, lb.	Wall Thickness, in.	Weight per Lineal Foot, Plain Ends, lb.	Wall Thickness, in.	Weight per Lineal Foot, Plain Ends, lb.	Wall Thickness, in.	Weight per Lineal Foot, Plain Ends, lb.	Wall Thickness, in.	Weight per Lineal Foot, Plain Ends, lb.
			SEAMLESS OPEN-HEARTH PIPE				SEAMLESS OPEN-HEARTH PIPE							
½	0.840	14	0 109	0.850	....	....	0.109	0.850	0.147	1.087	0.147	1.087	0.147	1.087
¾	1.050	14	0.113	1.130	....	....	0.113	1.130	0.154	1.473	0.154	1.473	0.1875	1.727
1	1.315	11½	0.133	1.678	....	....	0.133	1.678	0.179	2.171	0.179	2.171	0.21875	2.561
1¼	1.660	11½	0.140	2.272	....	....	0.140	2.272	0.191	2.996	0.191	2.996	0.250	3.764
1½	1.900	11½	0.145	2.717	....	....	0.145	2.717	0.200	3.631	0.200	3.631	0.28125	4.862
			LAP-WELDED OPEN-HEARTH PIPE				SEAMLESS OPEN-HEARTH PIPE							
2	2.375	11½	0.154	3.652	0.218	5.022	0.167	3.938	0.1875	4.380	0.250	5.673	0.3125	6.883
2½	2.875	8	0.203	5.793	0.276	7.661	0.203	5.793	0.217	6.160	0.276	7.661	0.375	10.012
3	3.500	8	0.216	7.575	0.300	10.252	0.216	7.575	0.241	8.388	0.3125	10.638	0.40625	13.423
3½	4.000	8	0.226	9.109	0.318	12.505	0.226	9.109	0.28125	11.170	0.34375	13.423	0.46875	17.678
4	4.500	8	0.237	10.790	0.337	14.983	0.237	10.790	0.28125	12.672	0.375	16.520	0.500	21.360
5	5.563	8	0.258	14.617	0.375	20.778	0.258	14.617	0.352	19.590	0.4375	23.949	0.625	32.961
6	6.625	8	0.280	18.974	0.432	28.573	0.288	19.491	0.385	25.658	0.500	32.707	0.6875	43.596
8	8.625	8	0.322	28.554	0.500	43.388	0.34375	30.402	0.46875	40 832	0.625	53.400	0.875	72.424
10	10.750	8	0.365	40.483	0.500	54.735	0.395	43.684	0.53125	57.979	0.750	80.101	1.0625	109.930
12	12.750	8	0.375	49.562	0.500	65.415	0.500	65.415	0.625	80.935	0.875	110.973	1.21875	150.095
14	14	8	0.40625	58.980	0.625	89.279	0.500	72.091	0.65625	93.524	0.9375	130.790	1.34375	181.635
16	16	8	0.46875	77.754	0.6875	112.433	0.53125	87.771	0.750	122.154	1.03125	164.864	1.500	232.293
18	18	8	0.500	93.451	0.750	138.174	0.59375	110.379	0.8125	149.146	1.15625	208.002	1.6875	293.996
20	20	8	0.5625	116.772	0.875	178.725	0.625	129.330	0.90625	184.806	1.28125	256.146	1.84375	357.524
24	24	8	0.625	163[a]	0.9375	240[a]	0.750	186.235	1.03125	252.975	1.500	360.455	2.1875	509.602

[a] Hammer weld pipe approximate manufacturing weight.

Test Specimens.

8. (*a*) Test specimens shall consist of sections cut from a pipe. Flattening test specimens shall be smooth on the ends and free from burrs, except when made on "crop" ends taken from welded pipe.

(*b*) Tension test specimens shall be cut longitudinally from the pipe and not flattened. Their widths shall be not less than the wall thickness of the pipe nor more than three times the wall thickness. The sides of specimens shall be parallel between gage marks. If desired, the tension test specimen may consist of full section of the pipe.

Specimens from welded pipe shall be taken at a point approximately 90 deg. from the weld.

(*c*) All specimens shall be tested at room temperature.

Number of Tests. 9. (*a*) From each lot of 500 lengths or less, of each size, two lengths shall be selected for test. Upon one of these the tension test specified in Section 4 shall be made. Upon both of them, the tests specified in Sections 6 (*b*), (*c*) or 7 shall be made.

(*b*) Each length shall be subjected to and withstand the hydrostatic test specified in Section 5.

(*c*) The flattening test described in Section 6 (*a*) shall be made on the crop ends cut from each length of welded pipe.

Retests. 10. (*a*) If the results of any physical or chemical tests of any lot do not conform to the requirements specified in Sections 3, 4, 6, and 7, retests of double the number of additional pipes shall be made, each of which shall conform to the requirements specified.

(*b*) Should a crop end fail in the flattening test, one retest may be made from the failed end.

STANDARD WEIGHTS

Standard Weights. 11. (*a*) The standard weights and nominal thicknesses for pipe of various diameters are given in Table I.

(*b*) Nipples shall be cut from pipe of the same weight and quality as described in these specifications.

Permissible Variations. 12. The weight of the pipe shall not exceed that specified in Table I by more than 5 per cent for the 250, 400, 600 and 900-lb.-per-sq.-in. standards, nor more than 10 per cent for the 1350-lb. standard.

Lengths. 13. Unless otherwise specified, pipe shall be furnished as to lengths in accordance with the following regular practice:

(*a*) The lengths required shall be specified in the order.

(*b*) No jointers are permitted.

WORKMANSHIP AND FINISH

Workmanship. 14. (*a*) For a pipe $1\frac{1}{2}$ in. in nominal diameter and smaller, the outside diameter at any point shall not vary more than $\frac{1}{64}$ in. over, nor more than $\frac{1}{32}$ in. under the standard size. For pipe 2 in. in nominal diameter and larger, the outside diameter shall not vary more than one per cent over or under the standard size.

(*b*) The minimum wall thickness at any point for welded, and seamless pipe shall not be more than 12.5 per cent under the nominal wall thickness specified.

15. Unless otherwise specified, pipe shall be furnished with plain ends. **Ends.**

16. The finished pipe shall be reasonably straight and free from injurious defects. All burrs at the ends of the pipe shall be removed. **Finish.**

MARKING

17. Each length of pipe shall be marked with appropriate symbols to show by whom manufactured, the classification as regards working steam pressure, and that it conforms to these specifications. **Marking.**

INSPECTION AND REJECTION

18. The inspector representing the purchaser shall have free entry, at all times while work on the contract of the purchaser is being performed, to all parts of the manufacturer's works which concern the manufacture of the pipe ordered. The manufacturer shall afford the inspector, without charge, all reasonable facilities to satisfy him that the pipe is being furnished in accordance with these specifications. All tests and inspection shall be made at the place of manufacture prior to shipment and at the manufacturer's expense, unless otherwise specified, and shall be so conducted as not to interfere unnecessarily with the operation of the works. **Inspection.**

19. Each length of pipe which develops injurious defects in shop working or application shall be rejected, and the manufacturer notified. **Rejection.**

EXPLANATORY NOTES

NOTE 1.—This contemplates temperatures from 450 to 750° F. (232 to 400° C.), or at the discretion of the designing engineer, higher temperatures with appropriate pressures may be used. Reference may be made to the dimensional standards reproduced in Table I for various pressures at this high temperature formulated at the suggestion of Sub-Committee No. 3 on Steel Flanges and Flanged Fittings of the Sectional Committee on Pipe Flanges and Fittings. This table is to be published as an appendix to the report of Sub-Committee No. 3 and, under the procedure of the American Engineering Standards Committee, will in due course be presented for approval as a Tentative American Standard by the American Society of Mechanical Engineers.

NOTE 2.—Low-carbon seamless tubing rather than medium-carbon should be used for cold bending or fusion welding. The purpose for which pipe is to be used should be stated on the face of the order.

NOTE 3.—The phosphorus limit for the finished pipe is set at 0.06 per cent maximum to permit re-phosphorizing to facilitate welding.

TENTATIVE SPECIFICATIONS
FOR
COLD-ROLLED STRIP STEEL[1]

Serial Designation: A 109 - 27 T

This is a **Tentative Standard,** published for the purpose of eliciting criticism and suggestions, and as such is subject to annual revision.

ISSUED, 1926; REVISED, 1927.

Material Covered.

1. These specifications cover five grades of commercial cold-rolled strip steel as follows:

Grade No. 1, or "Hard" Temper;
Grade No. 2, or "Half Hard" Temper;
Grade No. 3, or "Quarter Hard" Temper;
Grade No. 4, or "Planished" Temper;
Grade No. 5, or "Dead Soft" Temper.

Selection of Temper.

2. (*a*) These five grades of cold-rolled strip steel are commonly used for blanking, bending, forming, spinning and deep drawing.

(*b*) It should be understood, however, that the tempers and uses given are general. It is recommended that the purchaser furnish the manufacturer with a sample or sketch of the article to be made.

MANUFACTURE

Process.

3. The steel shall be made by the open-hearth process for temper Nos. 3, 4 and 5.

CHEMICAL REQUIREMENTS

Chemical Composition.

4. The steel shall conform to the following requirements as to chemical composition:

TEMPER NOS. 3, 4 AND 5

Carbon	0.05 to 0.15	per cent
Manganese	0.20 to 0.50	"
Phosphorus	not over 0.04	"
Sulfur	not over 0.055	"

TEMPER NOS. 1 AND 2

Carbon	not over 0.25	per cent

5. Samples for analysis shall be taken by machining the entire cross-section of the strip.

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[1] Criticisms of these Tentative Specifications are solicited and should be directed to Mr. G. H. Woodroffe, Secretary of Committee A-1 on Steel, Reading Iron Co., Reading, Pa.

PHYSICAL PROPERTIES AND TESTS

Tension Tests. 6. The material shall conform to the following requirements as to tensile properties:

	No. 1, Hard	No. 2, Half Hard		No. 3, Quarter Hard		No. 4, Planished	No. 5, Dead Soft
Tensile strength, minimum, lb. per sq. in. . .	60 000	55 000		45 000		40 000	40 000
		Min.	Max.	Min.	Max.	Min.	Min.
Elongation in 2 in., per cent:							
Below 0.062 in.		5	15.0	15.0	30.0	30.0	32.5
" 0.125 to 0.062 in. incl. . .		5	16.0	16.0	32.5	32.5	33.5
" 0.187 to 0.125 in. " . . .		5	17.5	17.5	33.5	33.5	36.0
" 0.250 to 0.187 in. " . . .		5	19.0	19.0	36.0	36.0	38.5
0.250 in. or over in thickness		5	20.0	20.0	38.5	38.5	40.0

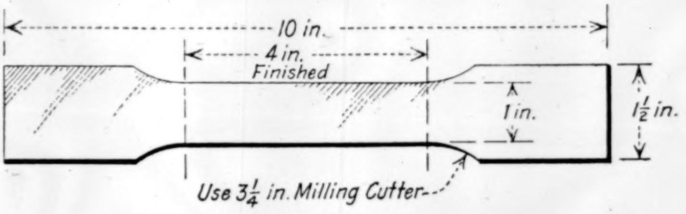

FIG. 1.—Tension Test Specimen.

Bend Tests. 7. The bend test specimens shall stand being bent cold as specified below without cracking on the outside of the bent portion:

No. 1, Hard	No. 2, Half Hard	No. 3, Quarter Hard	No. 4, Planished	No. 5, Dead Soft
Shall not be required to make bends in either direction of grain.	Shall bend to a sharp right angle across the grain.	Shall bend flat on itself across the grain and to a sharp right angle along the grain.	Shall bend flat upon itself both ways of the grain.	Shall bend flat upon itself both ways of the grain.

NOTE.—To bend across the grain means that the axis of the bend shall be at right angles to the direction of rolling.

To bend with the grain means that the axis of the bend shall be parallel to the direction of rolling

Test Specimens. 8. (*a*) The tension test specimens shall be cut in both a longitudinal and transverse direction from the strip except in the case of widths narrower than 10 in., in which case only longitudinal specimens shall be taken. The specimen shall be machined to the form and dimensions shown in Fig. 1.

NOTE.—The form of test specimen shown in Fig. 1 will be modified to agree with whatever form of test specimen is standardized for thin sheet metals by Committee E-1 on Methods of Testing. Also, the physical properties given in Section 6 may be modified later to agree with results obtained with a standardized form of test specimen.

(*b*) The test specimens shall be marked off for every 1-in. length within the 4-in. gage length. The percentage of elongation in 2 in. shall be determined by averaging the increase in length of the two 2-in. lengths that include the break.

(*c*) Bend test specimens may have the edges rounded.

PERMISSIBLE VARIATIONS IN DIMENSIONS

Thickness. 9. The thickness of the strip measured at a point ½ in. from the edge shall not vary from the thickness specified by more than the following plus or minus variations in inches:

Thickness, in	Width							
	Up to 2 in., inclusive	Over 2 to 4 in., inclusive	Over 4 to 6 in., inclusive	Over 6 to 8 in., inclusive	Over 8 to 12 in., inclusive	Over 12 to 16 in., inclusive	Over 16 to 24 in., inclusive	Over 24 in.
0.200 or over	0.003	0.004	0.005	0.005	0.006	0.006	0.007	0.008
Below 0.200 to 0.100	0.002	0.003	0.004	0.004	0.005	0.005	0.006	0.007
" 0.100 to 0.050	0.002	0.002	0.003	0.003	0.004	0.004	0.005	0.006
" 0.050 to 0.035	0.002	0.002	0.002	0.002	0.003	0.003	0.004	
" 0.035 to 0.015	0.0015	0.002	0.002	0.002	0.002			
" 0.015 to 0.010	0.001	0.0015	0.0015	0.0015	0.0015			
" 0.010 to 0.006	0.00075	0.001	0.001					
" 0.006	0.0005	0.0005	0.0005					

Width. 10. The width of the strip shall not vary from that specified by more than the following amounts:

MILL EDGE STEEL

	PLUS	MINUS
Up to 6 in. inclusive	$\frac{1}{16}$ in.	$\frac{1}{16}$ in.
Over 6 to 10 in.	$\frac{3}{32}$ in.	$\frac{3}{32}$ in.
Over 10 to 16 in.	$\frac{5}{32}$ in.	$\frac{5}{32}$ in.
Over 16 in.	$\frac{1}{4}$ in.	$\frac{1}{4}$ in.

SLIT, SHEARED OR FILE EDGE STEEL

	PLUS	MINUS
Up to 0.100 in.	0.015 in.	0.015 in.
0.100 to 0.200 "	0.025 in.	0.020 in.
0.200 to 0.300 "	0.035 in.	0.025 in
0.300 to 0.400 "	$\frac{1}{16}$ in	$\frac{1}{16}$ in.
0.400 to 0.500 "	$\frac{1}{8}$ in.	$\frac{1}{8}$ in.

ROUND OR SQUARE-ROLLED EDGE STEEL

WIDTH, IN.	THICKNESS, IN.	TOLERANCES IN WIDTH, PLUS OR MINUS, IN.
½ and narrower	$\frac{3}{16}$ and thinner	$\frac{1}{64}$
Over ½ to 1 incl	$\frac{3}{16}$ to 0.025 incl.	$\frac{1}{32}$
" 1 to 2	$\frac{1}{4}$ to 0.025 "	$\frac{1}{32}$
" 2 to 4	$\frac{1}{4}$ to 0.035 "	$\frac{3}{64}$
" 4 to 6	$\frac{1}{4}$ to 0.047 "	$\frac{3}{64}$

Strip wider than 6 in. is not furnished.

11. (*a*) Cold-rolled strip steel is usually furnished in coils, but may be furnished in cut lengths when ordered. Unless otherwise specified, the cut lengths will be 8 ft. and ends. When so furnished the allowance shall be plus 3 in. with no minus allowance. **Length.**

(*b*) When a definite length in inches is specified, the permissible variation shall be plus 1 in. with no minus allowance. Cutting to definite lengths over 36 in. does not relieve the buyer from scrap loss and short lengths will be included, cut to multiples, if so desired.

12. The standard for straightness shall be ½ in. bow in 8 ft. **Straightness.**

13. When flatness is an essential to the purchaser, it should be so specified. Flatness shall be determined by placing the strips in 8-ft. lengths on a flat surface, when no part of the strip shall rise more than ¼ in. from the surface. **Flatness.**

FINISH

14. Cold-rolled strip steel shall have a bright, smooth surface and shall be free from injurious defects. **Finish.**

15. The manufacturer shall afford the inspector representing the purchaser, without charge, all reasonable facilities to satisfy him that the material is being furnished in accordance with these specifications. Tests and inspection at the place of manufacture may be made prior to shipment, and such inspection shall be final. **Inspection.**

16. In case material is not inspected at the place of manufacture, the purchaser may make the tests to govern the acceptance or rejection of the material in his own laboratory or elsewhere. Such tests, however, shall be made at the expense of the purchaser.

17. All tests and inspection shall be so conducted as not to interfere unnecessarily with the operation of the works.

18. Unless otherwise specified, any rejections based on tests made in accordance with Section 16 shall be reported within ten working days from the receipt of samples. **Rejection.**

19. Material which shows injurious defects while being finished by the purchaser will be rejected, and the manufacturer shall be notified within 90 days from the date of the receipt of the material by the purchaser.

20. Samples tested in accordance with Section 16, which represent rejected material, shall be preserved for one month from the date of the test report. In case of dissatisfaction with the results of the tests, the manufacturer may make claim for a rehearing within that time. **Rehearing.**

TENTATIVE SPECIFICATIONS
FOR
ALLOY TOOL STEEL[1]

Serial Designation: A 115 - 27 T

This is a **Tentative Standard,** published for the purpose of eliciting criticism and suggestions, and as such is subject to annual revision.

ISSUED, 1927

Scope. 1. (*a*) These specifications cover alloy tool steels, the composition of which shall be as agreed upon by the purchaser and the vendor, with the permissible variations specified in Section 4.

(*b*) These steels are suitable for the manufacture of special purpose tools.

MANUFACTURE

Process. 2. The steel shall be made either by the crucible or electric-furnace process.

Annealing and Hardness. 3. The steel shall be furnished annealed unless otherwise specified. The microstructure, Brinell hardness and fracture tests shall be as agreed upon by the purchaser and the vendor.

CHEMICAL PROPERTIES AND TESTS

Chemical Composition. 4. The composition of the tool steels shall be as agreed upon by the purchaser and the vendor with the following permissible variations in composition:

		PERMISSIBLE VARIATIONS, PER CENT	
		OVER	UNDER
Carbon	1.25 or under	0.05	0.05
	Over 1.25	as agreed	as agreed
Manganese	1.00 or under	0.10	0.10
	Over 1.00	as agreed	as agreed
Phosphorus		0.005	....
Sulfur		0.005	....
Silicon		0.15	0.15
Chromium	1.00 or under	0.10	0.10
	Over 1.00 to 2.00, inclusive	0.15	0.15
	Over 2.00	as agreed	as agreed
Vanadium	0.50 and under	0.075	0.075
	0.50 to 1.00, inclusive	0.10	0.10
	Over 1.00	as agreed	as agreed
Tungsten	4.00 or under	0.25	0.25
	Over 4.00	as agreed	as agreed

Other elements as agreed.

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[1] Criticisms of these Tentative Specifications are solicited and should be directed to Mr. G. H. Woodroffe, Secretary of Committee A-1 on Steel, Reading Iron Co., Reading, Pa.

Method of Sampling.

5. (*a*) Milled samples for analysis shall be taken from the sample bar to represent the full cross-section, or drillings shall be taken by drilling a bar midway between the center and the surface, parallel to the axis of the bar. In either case the decarburized material shall be rejected.

(*b*) In general, the minimum depth to which the surface shall be removed before a sample is taken shall be in accordance with the following requirements:

THICKNESS OR DIAMETER, IN.	MATERIAL REMOVED, IN.
1 or under	$\frac{1}{32}$
Over 1 to 2½, inclusive	$\frac{1}{16}$
Over 2½ to 4, inclusive	$\frac{1}{8}$
Larger sizes	as agreed

(*c*) In the case of drill rod and other material of similar finish where freedom from decarburization is specified, samples shall be taken from the surface in addition to the methods described in Paragraph (*a*).

Standard Methods of Analysis.

6. In case of dispute, the chemical analysis shall be made in accordance with the Standard Methods of Chemical Analysis of Alloy Steels (Serial Designation: A 55) of the American Society for Testing Materials.[1]

MANUFACTURING TOLERANCES IN DIMENSIONS

Manufacturing Tolerances in Dimensions.

7. Variations in cross-sectional dimensions of the material shall not exceed the following amounts:

FORGED AND ROLLED MATERIAL

	PERMISSIBLE VARIATIONS, IN.	
	OVER	UNDER
½ in. or under	0.010 ($\frac{1}{100}$)	0.010 ($\frac{1}{100}$)
Over ½ in. to 1 in., inclusive	0.015 ($\frac{1}{64}$)	0.015 ($\frac{1}{64}$)
Over 1 in. to 1½ in., inclusive	0.031 ($\frac{1}{32}$)	0.031 ($\frac{1}{32}$)
Over 1½ in. to 2 in., inclusive	0.046 ($\frac{3}{64}$)	0.031 ($\frac{1}{32}$)
Over 2 in. to 4 in., inclusive	0.125 ($\frac{1}{8}$)	0.031 ($\frac{1}{32}$)
Over 4 in. to 6 in., inclusive	0.156 ($\frac{5}{32}$)	0.031 ($\frac{1}{32}$)
Over 6 in. to 8 in., inclusive	0.188 ($\frac{3}{16}$)	0.063 ($\frac{1}{16}$)
Over 8 in.	0.250 ($\frac{1}{4}$)	0.063 ($\frac{1}{16}$)
FINISHED MATERIAL (DRILL ROD)		
$\frac{7}{16}$ in. and under	0.0005	0.0005
Over $\frac{7}{16}$ in.	0.001	0.001

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[1] 1927 Book of A.S.T.M. Standards, Part I.

FINISH

Finish. 8. (*a*) The material shall be free from injurious defects and shall have a workmanlike finish.

(*b*) All drill rods shall be coated with a rust preventive.

MARKING

Marking. 9. (*a*) Identification marks shall be stamped on the material as agreed by the purchaser and the vendor. All identification marks shall be about $\frac{1}{4}$ in. in height when the size permits.

(*b*) In lieu of marking as specified in Paragraph (*a*), the ends of the bars and rods may be painted as agreed upon by the purchaser and the vendor.

Bundling Small Sizes. 10. All rods and bars of which the largest cross-sectional dimension is $\frac{3}{8}$ in. or less shall be boxed or bundled, each box or bundle to contain bars or rods of the same size, shape and class of material. A metal tag shall be securely attached to the wrapping wire or box. Rods and bars of cross-sectional dimensions exceeding $\frac{3}{8}$ in. and not exceeding $1\frac{1}{2}$ in., where convenient to purchaser and vendor, may be bundled and marked as specified above. Bundles shall be of suitable size to permit easy handling and shall be securely fastened.

INSPECTION AND REJECTION

Inspection. 11. The vendor shall afford the inspector, without charge, all reasonable facilities to satisfy him that the material is being furnished in accordance with these specifications.

Comparison with Selective Sample. 12. The steel shall correspond in quality and characteristics to the samples submitted under the specifications and approved by the purchaser.

Rejection. 13. Material which does not conform to the chemical composition and specified dimensions, or which at any time shows injurious defects inherent in the steel, will be rejected and the vendor shall be notified.

NOTE.—Recommended Practices for Heat Treatment have been prepared by the American Society for Steel Treating, and may be referred to as covering specific compositions within the limits of these specifications as follows:

Recommended Practice for the Heat Treatment of Non-Shrinking, Non-Deforming, Oil-Hardening Tool Steels; Recommended Practice for the Heat Treatment of Finishing Steel; Recommended Practice for the Heat Treatment of Taps and Milling Cutters; Tentative Recommended Practices for the Heat Treatment of Plain and Alloy-Steel Die Blocks.

TENTATIVE SPECIFICATIONS

FOR

ZINC-COATED (GALVANIZED) IRON OR STEEL TELEPHONE AND TELEGRAPH LINE WIRE[1]

Serial Designation: A 111 – 27 T

This is a **Tentative Standard,** published for the purpose of eliciting criticism and suggestions, and as such is subject to annual revision.

ISSUED, 1926; REVISED, 1927.

Scope.

1. These specifications cover galvanized iron or steel wire for use in telephone and telegraph transmission. The weight classification and all test procedure shall be in accordance with the Tentative Methods of Testing Zinc-Coated (Galvanized) Iron and Steel Wire and Wire Products (Serial Designation: A 110 – 27 T) of the American Society for Testing Materials.[2]

MANUFACTURE

Zinc Coating.

2. The zinc used for the coating shall be any grade of zinc conforming to the requirements of the Standard Specifications for Spelter (Serial Designation: B 6) of the American Society for Testing Materials.[3]

Base Metal.

3. The base metal shall be mild homogeneous iron or steel of such quality and purity that, when drawn and uniformily annealed, the finished wire will have the properties and characteristics herein specified.

WEIGHT AND UNIFORMITY OF COATING

Tests of Coating.

4. The weight and uniformity of the coating shall be defined and tested in accordance with the requirements of the Tentative Methods of Testing Zinc-Coated (Galvanized) Iron and Steel Wire and Wire Products (Serial Designation: A 110 – 27 T) of the American Society for Testing Materials.[2]

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[1] Criticisms of these Tentative Specifications are solicited and should be directed to Mr. James Aston, Secretary of Committee A-5 on Corrosion of Iron and Steel, Department of Mining and Metallurgy, Carnegie Institute of Technology, Pittsburgh, Pa.

[2] See p. 696.

[3] 1927 Book of A.S.T.M. Standards, Part I.

Weight and Uniformity of Coating. 5. The weight and uniformity of the coating of the various gages of wire shall be as specified by the purchaser and in accordance with the weights and dips designated in Table I.

Table I.—Commercially Available Zinc-Coated Iron or Steel Telephone and Telegraph Wire.

Nominal Diameter of Wire, in.	Size, B. W. G.	Class Designation Wt. 8 Dip 4	Class Designation Wt. 7 Dip 3½
0.238	4	✓	...
0.203	6	✓	...
0.165	8	✓	...
0.148	9	✓	...
0.134	10	✓	...
0.120	11	✓	...
0.109	12	✓	...
0.083	14	...	✓

Note.—Sizes in which any given weight of coating may be regularly obtained in the open market are indicated by a ✓ opposite the gage in the above table.

PHYSICAL PROPERTIES AND TESTS

(*A*) *Mechanical Test of Coating*[1]

(*B*) *Mechanical Test of Wire*

Tensile Strength. 6. The Tensile strength of the zinc-coated iron or steel wire shall conform to the values given in Table II:

Table II.—Minimum Tensile Strengths, lb.

Nominal Diameter of Wire, in.	Size, B. W. G.	Less than 5000 Mile-Ohm Resistivity	5000 to 5700 Mile-Ohm Resistivity	Over 5700 Mile-Ohm Resistivity
0.238	4	2028	2270	2433
0.203	6	1475	1650	1770
0.165	8	975	1090	1170
0.148	9	785	880	942
0.134	10	645	720	774
0.120	11	515	575	618
0.109	12	425	475	510
0.083	14	247	275	297

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[1] If desired by the purchaser a wrap test may be specified for the zinc coating. The purchaser shall specify coatings passing the wrap test as described in the Tentative Methods of Testing Zinc-Coated (Galvanized) Iron and Steel Wire and Wire Products (Serial Designation: A 110 – 27 T) of the American Society for Testing Materials. (See p. 696.) The coatings on all commercially available wire manufactured to meet these specifications will pass a wrap test on mandrel No. 12. Coatings are available passing wrap tests as low as mandrel No. 1. Coatings passing wrap tests on mandrels of intermediate sizes may be specified.

7. The finished wire shall have an elongation of not less than 10 per cent in 10 in. **Elongation.**

8. The wire shall be capable of withstanding not less than 35 twists in a length equivalent to 100 diameters. **Twists.**

(*C*) *Electrical Properties*

9. The resistivity of the wire expressed in pounds per mile-ohm (product of resistance in ohms per mile and the weight in pounds per mile), at 20° C. (68° F.) shall conform to the requirements given in Table III. **Resistivity.**

TABLE III.—ALLOWABLE VARIATIONS IN RESISTIVITY, MILE-OHM

	LESS THAN 5000 MILE-OHM RESISTIVITY	5000 TO 5700 MILE-OHM RESISTIVITY	OVER 5700 MILE-OHM RESISTIVITY
Nominal average	4750	5350	6000
Maximum of any sample	5000	5700	7000

SIZE AND PERMISSIBLE VARIATIONS

10. (*a*) The size of the finished wire shall be expressed as the diameter of the wire in decimal fractions of an inch. **Size.**

(*b*) The permissible variations from nominal diameter shall be: **Permissible Variations.**

For wire 0.109 in. or over in diameter	±0.004 in.
For wire under 0.109 in. in diameter	±0.003 in.

(*c*) The wire of each coil shall be gaged in three places; one near each end, and one approximately at the middle. **Gage.**

(*d*) A coil shall be rejected if the average gage is not within the limits specified in Paragraph (*b*).

WORKMANSHIP AND FINISH

11. (*a*) The wire shall be free from splints, scales, inequalities, flaws and other imperfections not consistent with good commercial practice. **Surface Finish.**

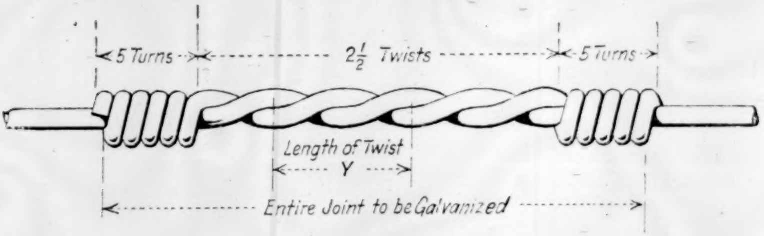
(*b*) To insure the removal of defective ends from the wire, the manufacturer shall cut off as much as may be necessary from the ends of each coil.

12. The zinc coating shall be smooth and continuous. **Coating.**

PACKING AND MARKING

13. (*a*) The finished wire shall be furnished in compact coils reasonably symmetrical in shape. The diameter of the eye of each coil shall not be less than 20 nor more than 22 in., except that in the case of wire of 0.203 in. or larger in diameter, the maximum diameter of the eye may be 24 in. **Packing.**

(*b*) Each coil of wire, 0.134 in. or under in diameter, shall consist of one continuous piece, without joints. Each coil of wire 0.148 in. or over in diameter shall consist of one continuous piece, except that not more than 10 per cent of the coils in any lot offered for inspection may contain one joint per coil, provided the joint is made in accordance with the sketch shown on Fig. 1 and galvanized after the joint is made.



Nominal Diameter of Wire, in.	Size, B. w. g.	Distance "Y"
0.238	4	$1\frac{3}{4}$ in.
0.203	6	$1\frac{1}{2}$ in.
0.165	8	$1\frac{1}{4}$ in.
0.148	9	1 in.
0.134	10	1 in.
0.120	11	$\frac{3}{4}$ in
0.109	12	$\frac{3}{4}$ in.
0.083	14	$\frac{5}{8}$ in.

FIG. 1.—Standard Line Wire Joint.

(*c*) The length of wire in each coil shall conform to the values given in Table IV. The weight of any coil shall not vary by more than 10 per cent from the specified weights.

TABLE IV.—MINIMUM AMOUNT OF WIRE IN EACH COIL.

Nominal Diameter of Wire, in.	Size, B. w. g.	Length of Wire in Coil
0.238	4	$\frac{1}{4}$ mile or 197 lb.
0.203	6	$\frac{1}{3}$ mile or 191 lb.
0.165	8	$\frac{1}{2}$ mile or 189 lb.
0.148	9	$\frac{1}{2}$ mile or 152 lb.
0.134	10	$\frac{1}{2}$ mile or 126 lb.
0.120	11	$\frac{1}{2}$ mile or 100 lb.
0.109	12	$\frac{1}{2}$ mile or 82 lb.
0.083	14	$\frac{1}{2}$ mile or 48 lb.

Marking. 14. Each coil shall be securely bound in four separate places, equally spaced, with at least two wrappings of galvanized iron wire, the binding wire to be not smaller than 0.109 in. in diameter. The outer end of each coil shall be bent back over the binding wire to prevent it from crowding into the coil. To each coil shall be securely wired a metal tag showing the size and kind of wire, weight of coil, and the manufacturer's name.

INSPECTION, SAMPLING AND REJECTION

Inspection.

15. The manufacturer shall afford the inspector representing the purchaser, without charge, suitable facilities and equipment for making the tests required by these specifications, in order that he may satisfy himself that the material is being furnished in accordance with these specifications.

Sampling and Rejection.

16. The inspector shall visually examine the entire shipment or lot of coils for surface imperfections. If, after testing as described in this Section, over 3 per cent of the coils in the entire lot are found defective, the purchaser may reject the entire lot. One-third of the coils shall be examined to determine whether the diameter is within the specified limits. If over 3 per cent of these coils do not conform to the requirements for the diameter, the purchaser may reject the entire lot. The inspector shall select at random during the visual inspection one sample coil from every ten coils in the lot but not less than three from the entire lot. One sample of suitable length shall be cut from each coil selected for use in making the stripping, uniformity, and physical tests of the coating and wire as described in Sections 4, 5, 6, 7, and 8. If more than 3 per cent of the samples selected for test, in no case less than three samples, fail to pass any of these tests, the purchaser may reject the entire lot. If not more than 3 per cent of the samples fail, a second set of samples, consisting of 2 specimens from each of the coils from which the original non-conforming samples were taken, shall be cut and tested for the non-comforming properties. If any of these samples fail, the purchaser may reject the entire lot.

TENTATIVE SPECIFICATIONS

FOR

ZINC-COATED (GALVANIZED) IRON OR STEEL TIE WIRES[1]

Serial Designation: A 112 - 27 T

This is a **Tentative Standard,** published for the purpose of eliciting criticism and suggestions, and as such is subject to annual revision.

ISSUED, 1926; REVISED, 1927.

Scope. 1. These specifications cover galvanized iron or steel tie wires for use in tying galvanized iron or steel telephone and telegraph line wire to insulators. The weight classification and all test procedure shall be in accordance with the Tentative Methods of Testing Zinc-Coated (Galvanized) Iron and Steel Wire and Wire Products (Serial Designation: A 110 - 27 T) of the American Society for Testing Materials.[2]

MANUFACTURE

Zinc Coating. 2. The zinc used for the coating shall be any grade of zinc conforming to the requirements of the Standard Specifications for Spelter (Serial Designation: B 6) of the American Society for Testing Materials.[3]

Base Metal. 3. The base metal of the tie wires shall be of a soft grade of iron or steel wire which shall have the properties and characteristics herein specified.

WEIGHT AND UNIFORMITY OF COATING

Tests of Coating. 4. The weight and uniformity of the coating shall be defined and tested in accordance with the requirements of the Tentative Methods of Testing Zinc-Coated (Galvanized) Iron and Steel Wire and Wire Products (Serial Designation: A 110 - 27 T) of the American Society for Testing Materials.[2]

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[1] Criticisms of these Tentative Specifications are solicited and should be directed to Mr. James Aston, Secretary of Committee A-5 on Corrosion of Iron and Steel, Department of Mining and Metallurgy, Carnegie Institute of Technology, Pittsburgh, Pa.

[2] See p. 696.

[3] 1927 Book of A.S.T.M. Standards, Part I.

Weight and Uniformity of Coating. 5. The weight and uniformity of the coating of the various gages of wire shall be as specified by the purchaser and in accordance with the weights and dips designated in Table I.

TABLE I.—COMMERCIALLY AVAILABLE ZINC-COATED IRON OR STEEL TIE WIRES.

Nominal Diameter of Wire, In.	Size, B. w. G.	Class Designation	
		Wt. 8 Dip 4	Wt. 7 Dip 3½
0.165	8	✓	...
0.148	9	✓	...
0.134	10	✓	...
0.109	12	✓	...
0.083	14	...	✓

NOTE.—Sizes in which any given weight of coating may be regularly obtained in the open market are indicated by a ✓ opposite the gage in the above table.

PHYSICAL PROPERTIES AND TESTS

(*A*) *Mechanical Test of Coating*[1]

(*B*) *Mechanical Test of Wire*

Tensile Strength. 6. The tensile strength of any individual test sample shall not exceed 60,000 lb. per sq. in.

Elongation. 7. The finished tie wire shall have an elongation of not less than 12 per cent in 10 in.

SIZE AND PERMISSIBLE VARIATIONS

Size. 8. (*a*) The size of the finished wire shall be expressed as the diameter of the wire in decimal fractions of an inch.

Permissible Variations. (*b*) The permissible variation from nominal diameter shall be:

For wire 0.109 in. or over in diameter	±0.004 in.
For wire under 0.109 in. in diameter	±0.003 in.

Gage. (*c*) Three tie wires from each test bundle taken as described in Section 17 shall be gaged in at least three separate places.

(*d*) The bundle shall be rejected if the average gage is not within the limits specified in Paragraph (*b*).

Diameter. 9. The diameters of the respective sizes of tie wires shall be 0.165, 0.148, 0.134, 0.109, and 0.083 in.

Length. 10. The length of the tie wires shall not vary by more than ⅛ in. over or under the specified length.

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[1] If desired by the purchaser a wrap test may be specified for the zinc coating. The purchaser shall specify coatings passing the wrap test as described in the Tentative Methods of Testing Zinc-Coated (Galvanized) Iron and Steel Wire and Wire Products (Serial Designation: A 110 - 27 T) of the American Society for Testing Materials. (See p. 696.) The coatings on all commercially available wire manufactured to meet these specifications will pass a wrap test on mandrel No. 12. Coatings are available passing wrap tests as low as mandrel No. 1. Coatings passing wrap tests on mandrels of intermediate sizes may be specified.

WORKMANSHIP AND FINISH

Surface Finish. 11. The wire shall be free from splints, scales, inequalities, flaws, and other imperfections not consistent with good commercial practice.

Coating. 12. The zinc coating shall be smooth and continuous.

PACKING AND MARKING

Weight of Package. 13. Bundles of iron or steel tie wires shall be packed as specified but in no case shall exceed 50 lb.

Packing. 14. Each bundle shall be bound at the middle with galvanized iron wire and then wrapped with burlap or heavy paper and bound near each end with the same kind of wire used for the inner binding.

Marking. 15. To each bundle shall be securely fastened a strong tag showing the size of the tie wire, gross weight, and the manufacturer's name.

INSPECTION, SAMPLING AND REJECTION

Inspection. 16. The manufacturer shall afford the inspector representing the purchaser, without charge, suitable facilities and equipment for making the tests required by these specifications, in order that he may satisfy himself that the material is being furnished in accordance with these specifications.

Sampling and Rejection. 17. The inspector shall visually examine the entire shipment or lot of bundles for surface imperfections. If, after testing as described in this Section, over 3 per cent of the bundles in the entire lot are found defective, the purchaser may reject the entire lot. One-third of the bundles shall be examined to determine whether the diameter is within the limits specified in Sections 8 and 9. If over 3 per cent of these bundles do not conform to the requirements for the diameter, the purchaser may reject the entire lot. The inspector shall select at random during the visual inspection, one sample bundle from every ten bundles in the lot but not less than three from the entire lot. From each bundle thus selected, one sample tie wire shall be taken for each of the stripping, uniformity, and physical tests of the coating and wire as described in Sections 4, 5, 6, and 7. If more than 3 per cent of the samples selected for test, in no case less than 3 samples, fail to pass any of these tests, the purchaser may reject the entire lot. If not more than 3 per cent of the samples fail, a second set of samples, consisting of 2 specimens from each of the bundles from which the original non-conforming samples were taken, shall be cut and tested for the non-conforming properties. If any of these samples fail, the purchaser may reject the entire lot.

TENTATIVE SPECIFICATIONS
FOR
ZINC-COATED (GALVANIZED) WIRE FENCING[1]

Serial Designation: A 116 - 27 T

This is a **Tentative Standard,** published for the purpose of eliciting criticism and suggestions, and as such is subject to annual revision.

ISSUED, 1927.

Scope. 1. These specifications cover zinc-coated woven-wire fencing, commercially known as farm or field fencing. The weight classification and all test procedure shall be in accordance with the Tentative Methods of Testing Zinc-Coated (Galvanized) Iron and Steel Wire and Wire Products (Serial Designation: A 110 - 27 T) of the American Society for Testing Materials.[2]

MANUFACTURE

Style and Size. 2. It is recommended that styles and sizes of fence fabrics covered by these specifications be in accordance with those recommended by the U. S. Department of Commerce in its Simplified Practice Recommendation No. 9 or its subsequent recommendations.

Zinc Coating. 3. The zinc used for the coating shall be any grade of zinc conforming to the requirements of the Standard Specifications for Spelter (Serial Designation: B 6) of the American Society for Testing Materials.[3]

Base Metal. 4. The base metal of the fabric shall be of a good commercial quality of steel or iron wire. If copper is desired, the copper content shall not be less than 0.2 per cent.

WEIGHT AND UNIFORMITY OF COATING

Tests of Coating. 5. The weight and uniformity of the coating shall be defined and tested in accordance with the requirements of the Tentative Methods of Testing Zinc-Coated (Galvanized) Iron and Steel Wire and Wire Products (Serial Designation: A 110 - 27 T) of the American Society for Testing Materials.[2]

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[1] Criticisms of these Tentative Specifications are solicited and should be directed to Mr. James Aston, Secretary of Committee A-5 on Corrosion of Iron and Steel, Department of Mining and Metallurgy, Carnegie Institute of Technology, Pittsburgh, Pa.

[2] See p. 696.

[3] 1927 Book of A.S.T.M. Standards, Part I.

Weight and Uniformity of Coating. 6. The weight and uniformity of the coating for the various gages of wire composing the fencing shall be as specified by the purchaser and in accordance with the weights and dips designated in Table I.

TABLE I.—COMMERCIALLY AVAILABLE ZINC-COATED FENCE WIRE.

NOMINAL DIAMETER OF WIRE, IN.	SIZE, STEEL WIRE GAGE	CLASS DESIGNATION			
		WT. 7 DIP 4	WT. 5 DIP 3	WT. 3½ DIP 2	WT. 2 DIP 1
0.192	6	✓	✓	...	...
0.177	7	✓	✓	...	...
0.162	8	✓	✓	...	...
0.148	9	✓	✓	✓	...
0.135	10	...	✓	✓	...
0.120	11	...	✓	✓	✓
0.105	12	...	✓	✓	✓
0.098	12½	...	...	✓	✓
0.092	13	...	...	✓	✓
0.080	14	...	...	✓	✓
0.076	14½	...	...	✓	✓
0.072	15	...	...	...	✓
0.063	16	...	...	...	✓
0.054	17	...	...	...	✓

NOTE.—Sizes in which any given weight of coating may be regularly obtained in the open market are indicated by a ✓ opposite the gage in the above table.

In special cases wire may be obtained carrying Wts. 7 and 5 on smaller gages than indicated in the above table.

SIZE AND PERMISSIBLE VARIATIONS

Size. 7. (*a*) The size of the finished wire shall be expressed as the diameter of the wire in decimal fractions of an inch.

Permissible Variations. (*b*) The permissible variations from the nominal diameter shall be:

For wire, 0.109 in. or over in diameter	±0.004 in.
For wire, under 0.109 in. in diameter	±0.003 in.

PACKING AND MARKING

Packing and Marking. 8. Each length of fencing shall be tightly rolled and firmly tied. For ease of handling, consideration should be given to the weight of the roll, depending upon the length of fencing. Each roll shall carry a tag showing the class of coating, nominal weight of coating corresponding to Table I, the gage of the wire, the length of fencing in the roll, type of fencing, and the manufacturer's name or mark.

INSPECTION, SAMPLING AND REJECTION

Inspection. 9. The manufacturer shall afford the inspector representing the purchaser, without charge, all reasonable facilities to satisfy himself that the material is being furnished in accordance with these specifications. All tests and inspection shall be made at the place of manufacture, prior to shipment, and shall be so conducted as not to interfere unnecessarily with the operation of the works.

Billing.

10. All rolls of fencing accepted by the purchaser shall be billed to him on the basis of the original weight or footage of the rolls before sampling.

Sampling and Rejection.

11. For purpose of tests, one roll from each twenty rolls of fencing, but not less than three rolls, of each lot shall be taken for a sample. Sufficient length of the fencing shall be cut from the end of the roll to include three stay wires. The test specimens for the line wire shall be cut between these three stays. The test specimens for the stays shall be cut from two of these three stays. All wire knots, wraps or welds shall be excluded from the test. The resultant specimens of line and stay wire from each sample roll shall be put into separate groups. Three specimens from each of these groups shall be subjected to the test for the weight of coating in accordance with Sections 5 and 6, and three specimens from each of these groups shall be subjected to the test for uniformity of coating, in accordance with Sections 5 and 6. If 20 per cent of the specimens tested by the weight-of-coating test, or the uniformity test, fail to meet the requirements of these specifications, additional specimens shall be selected as described above, and a retest for the non-conforming properties shall be made; and if 20 per cent of these specimens fail, the entire lot thus inspected may be rejected.

TENTATIVE SPECIFICATIONS
FOR
ZINC-COATED CHAIN-LINK FENCE FABRIC GALVANIZED AFTER WEAVING[1]

Serial Designation: A 117 – 27 T

This is a **Tentative Standard,** published for the purpose of eliciting criticism and suggestions, and as such is subject to annual revision.

Issued, 1927.

Scope. 1. These specifications cover zinc-coated chain-link fence fabric in which the individual pickets are helically wound and interwoven in the form of a continuous link fabric without knots or ties. The weight classification and all test procedure shall be in accordance with the Tentative Methods of Testing Zinc-Coated (Galvanized) Iron and Steel Wire and Wire Products (Serial Designation: A 110 – 27 T) of the American Society for Testing Materials.[2]

2. These specifications cover the usual sizes of wire and mesh as follows:

Nominal Diameter of Wire, in.	Size, Steel Wire Gage	Size of Mesh, in.	Height of Fence Fabric, in.
0.192	6	2	36, 42, 48, 60, 72, 84, 96, 108, 120, 144
0.148	9	2	36, 42, 48, 60, 72, 84, 96, 108, 120, 144
0.120	11	2	36, 42, 48, 60, 72, 84, ...
0.120	11	1¾	.. .. 96, 108, 120, 144

MANUFACTURE

Weave. 3. The wire shall be woven in the form of approximately uniform square mesh throughout, having parallel sides and horizontal and vertical diagonals of approximately uniform dimensions. The top and bottom of the fabric shall be knuckled or barbed as specified. The fencing shall be galvanized after weaving.

Zinc Coating. 4. The zinc used for the coating shall be any grade of zinc conforming to the requirements of the Standard Specifications for Spelter

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[1] Criticisms of these Tentative Specifications are solicited and should be directed to Mr. James Aston, Secretary of Committee A-5 on Corrosion of Iron and Steel, Department of Mining and Metallurgy, Carnegie Institute of Technology, Pittsburgh, Pa.

[2] See p. 696.

(Serial Designation: B 6) of the American Society for Testing Materials.[1]

Base Metal.

5. The base metal of the fabric shall be of a good commercial quality of steel or iron wire. If copper is desired, the copper content shall not be less than 0.2 per cent.

WEIGHT AND UNIFORMITY OF COATING

Tests of Coating.

6. The weight and uniformity of the coating shall be defined and tested in accordance with the requirements of the Tentative Methods of Testing Zinc-Coated (Galvanized) Iron and Steel Wire and Wire Products (Serial Designation: A 110 - 27 T) of the American Society for Testing Materials.[2]

Weight and Uniformity of Coating.

7. The weight and uniformity of the coating for the various gages of wire composing the fencing shall be as specified by the purchaser and in accordance with the weights and dips designated in Table I.

TABLE I.—COMMERCIALLY AVAILABLE ZINC-COATED CHAIN-LINK FENCE FABRIC GALVANIZED AFTER WEAVING.

Nominal Diameter of Wire, in.	Size, Steel Wire Gage	Class Designation Minimum Wt. 12 Dip 4
0.192	6	√
0.148	9	√
0.120	11	√

NOTE.—Sizes in which any given weight of coating may be regularly obtained in the open market are indicated by a √ opposite the gage in the above table.

PACKING AND MARKING

Packing and Marking.

8. The continuous lengths of fence fabric shall be 25, 50, or 100 ft., or as specified. Each length of fabric shall be tightly rolled and firmly tied. For ease of handling, consideration should be given to the weight of the roll, depending upon the length of fabric. Each roll shall carry a tag showing the class of coating, the nominal weight of coating, the gage of the wire, the length of fencing in the roll, and the manufacturer's name or mark.

INSPECTION, SAMPLING AND REJECTION

Inspection.

9. The manufacturer shall afford the inspector representing the purchaser, without charge, all reasonable facilities to satisfy himself that the material is being furnished in accordance with these specifications. All tests and inspection shall be made at the place of manu-

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[1] 1927 Book of A.S.T.M. Standards, Part I.

[2] See p. 696.

facture, prior to shipment, and shall be so conducted as not to interfere unnecessarily with the operation of the works.

Billing. 10. All rolls of fencing accepted by the purchaser shall be billed to him on the basis of the original weight or footage of the rolls before sampling.

Sampling and Rejection. 11. For purpose of tests, one roll for each 10 per cent of the rolls of fabric in shipments of less than fifty rolls shall be taken as a sample. One roll representing each 5 per cent of the rolls in shipments of over fifty rolls shall be taken as a sample. In no case shall there be less than three samples taken. The specimens for testing shall consist of one square foot of woven fencing selected at any point in the width of the fence fabric, exclusive of the twisted or knuckled portions, and taken from the end of the roll. A specimen from each sample shall be subjected to the test for the weight of coating in accordance with Sections 6 and 7, and a specimen from each sample shall be subjected to the test for uniformity of coating in accordance with Sections 6 and 7.

By means of the following formulas, the wire surface area in square feet contained in one square foot of fabric can be calculated to facilitate the computation of the surface area of the specimens:

Square feet of wire surface of Size 6 (Steel Wire Gage) wire = $0.516\, W$
" " " " " " " 9 (" " ") " = $0.674\, W$
" " " " " " " 11 (" " ") " = $0.830\, W$

where W is the weight in pounds of wire in one square foot of fabric after being stripped of galvanizing.

If any specimen tested fails to meet the requirements of these specifications, two additional specimens shall be cut from the remainder of the sample and tested, both of which shall meet the requirements in every respect or the lot represented by the sample may be rejected.

TENTATIVE SPECIFICATIONS
FOR
ZINC-COATED CHAIN-LINK FENCE FABRIC GALVANIZED BEFORE WEAVING[1]

Serial Designation: A 118 - 27 T

This is a **Tentative Standard,** published for the purpose of eliciting criticism and suggestions, and as such is subject to annual revision.

ISSUED, 1927.

Scope. 1. These specifications cover zinc-coated chain-link fence fabric in which the individual pickets are helically wound and interwoven in the form of a continuous link fabric without knots or ties. The weight classification and all test procedure shall be in accordance with the Tentative Methods of Testing Zinc-Coated (Galvanized) Iron and Steel Wire and Wire Products (Serial Designation: A 110 - 27 T) of the American Society for Testing Materials.[2]

2. These specifications cover the usual sizes of wire and mesh as follows:

Nominal Diameter of Wire, in.	Size, Steel Wire Gage	Size of Mesh, in.	Height of Fence Fabric, in.
0.192.......	6	2	36, 42, 48, 60, 72, 84, 96, 108, 120, 144
0.148.......	9	2	36, 42, 48, 60, 72, 84, 96, 108, 120, 144
0.120.......	11	2	36, 42, 48, 60, 72, 84, ...
0.120.......	11	1¾	.. .. 96, 108, 120, 144

MANUFACTURE

Weave. 3. The wire shall be woven in the form of approximately uniform square mesh throughout, having parallel sides and horizontal and vertical diagonals of approximately uniform dimensions. The top and bottom of the fabric shall be knuckled or barbed as specified. The fencing shall be galvanized before weaving.

Zinc Coating. 4. The zinc used for the coating shall be any grade of zinc conforming to the requirements of the Standard Specifications for Spelter

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[1] Criticisms of these Tentative Specifications are solicited and should be directed to Mr. James Aston, Secretary of Committee A-5 on Corrosion of Iron and Steel, Department of Mining and Metallurgy, Carnegie Institute of Technology, Pittsburgh, Pa.

[2] See p. 696.

(Serial Designation: B 6) of the American Society for Testing Materials.[1]

Base Metal. 5. The base metal of the fabric shall be of a good commercial quality of steel or iron wire. If copper is desired, the copper content shall not be less than 0.2 per cent.

WEIGHT AND UNIFORMITY OF COATING

Tests of Coating. 6. The weight and uniformity of the coating shall be defined and tested in accordance with the requirements of the Tentative Methods of Testing Zinc-Coated (Galvanized) Iron and Steel Wire and Wire Products (Serial Designation: A 110 - 27 T) of the American Society for Testing Materials.[2]

7. The weight and uniformity of the coating for the various gages of wire composing the fencing shall be as specified by the purchaser and in accordance with the weights and dips designated in Table I.

TABLE I.—COMMERCIALLY AVAILABLE ZINC-COATED CHAIN-LINK FENCE FABRIC GALVANIZED BEFORE WEAVING.

Nominal Diameter of Wire, in.	Size, Steel Wire Gage	Class Designation	
		Wt. 7 Dip 4	Wt. 5 Dip 3
0.192	6	√	√
0.148	9	√	√
0.120	11	...	√

NOTE.—Sizes in which any given weight of coating may be regularly obtained in the open market are indicated by a √ opposite the gage in the above table.

SIZE AND PERMISSIBLE VARIATIONS

Size. 8. (*a*) The size of the finished wire shall be expressed as the diameter of the wire in decimal fractions of an inch.

Permissible Variations. (*b*) The permissible variations from the nominal diameter shall be plus or minus 0.004 in.

PACKING AND MARKING

Packing and Marking. 9. The continuous lengths of fence fabric shall be 25, 50, or 100 ft., or as specified. Each length of fabric shall be tightly rolled and firmly tied. For ease of handling, consideration should be given to the weight of the roll, depending upon the length of fabric. Each roll shall carry a tag showing the class of coating, the nominal weight of coating, the gage of the wire, the length of fencing in the roll, and the manufacturer's name or mark.

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[1] 1927 Book of A.S.T.M. Standards, Part I.

[2] See p. 696.

INSPECTION, SAMPLING AND REJECTION

Inspection.

10. The manufacturer shall afford the inspector representing the purchaser, without charge, all reasonable facilities to satisfy himself that the material is being furnished in accordance with these specifications. All tests and inspection shall be made at the place of manufacture, prior to shipment, and shall be so conducted as not to interfere unnecessarily with the operation of the works.

Billing.

11. All rolls of fencing accepted by the purchaser shall be billed to him on the basis of the original weight or footage of the rolls before sampling.

Sampling and Rejection.

12. For purpose of tests, one roll for each 10 per cent of the rolls of fabric in shipments of less than fifty rolls shall be taken as a sample. One roll representing each 5 per cent of the rolls in shipments of over fifty rolls shall be taken as a sample. In no case shall there be less than three samples taken. The specimens for testing shall consist of one square foot of woven fencing selected at any point in the width of the fence fabric, exclusive of the twisted or knuckled portions, and taken from the end of the roll. A specimen from each sample shall be subjected to the test for the weight of coating in accordance with Sections 6 and 7; and a specimen from each sample shall be subjected to the test for the uniformity of coating in accordance with Sections 6 and 7.

By means of the following formulas, the wire surface area in square feet contained in one square foot of the fabric can be calculated, to facilitate the computation of the surface area of the specimens:

Square feet of wire surface of Size 6 (Steel Wire Gage) wire = $0.516\ W$
" " " " " " " 9 (" " ") " = $0.674\ W$
" " " " " " " 11 (" " ") " = $0.830\ W$

where W = the weight in pounds of wire in one square foot of fabric after being stripped of galvanizing.

If any specimen tested fails to meet the requirements of these specifications, two additional specimens shall be cut from the remainder of the sample and tested, both of which must meet with the requirements in every respect or the lot represented by the sample may be rejected.

TENTATIVE METHODS OF TESTING ZINC-COATED (GALVANIZED) IRON AND STEEL WIRE AND WIRE PRODUCTS[1]

Serial Designation: A 110 – 27 T

This is a **Tentative Standard,** published for the purpose of eliciting criticism and suggestions, and as such is subject to annual revision.

ISSUED, 1927.

Scope. 1. These methods cover the testing of zinc coatings applied by the hot-dip and electro-deposition methods to iron and steel wire.

WEIGHT OF COATING

Weights of Coating Test. 2. Weights of coating shall be determined by the Hydrochloric Acid - Antimony Chloride Method as described in the Standard Methods of Determining Weight of Coating on Zinc-Coated Articles (Serial Designation: A 90) of the American Society for Testing Materials.[2]

Classes of Coating Weights. 3. The classes of weights of coating per unit area on zinc-coated products shall be designated in accordance with the following illustrative scheme:

Class Designation	Weight of Coating, oz. per sq. ft.
Wt. 15	Minimum of 1.5
Wt. 10	" " 1.0
Wt. 6	" " 0.6
Wt. 1	" " 0.1

This classification may be extended or interpolated to provide a selection of classes as needed in preparing specifications for zinc-coated wire and wire products.

Rejection. 4. The weight of coating of any class of wire being found on inspection to be heavier than that defined for the class designated, shall not constitute cause for rejection unless so specified on the purchase order.

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[1] Criticisms of these Tentative Methods are solicited and should be directed to Mr. James Aston, Secretary of Committee A-5 on Corrosion of Iron and Steel, Department of Mining and Metallurgy, Carnegie Institute of Technology, Pittsburgh, Pa.

[2] 1927 Book of A.S.T.M. Standards, Part I.

UNIFORMITY OF COATING

5. The uniformity of zinc coatings shall be determined by the Preece test as described in the appendix to the Standard Methods of Determining Weight of Coating on Zinc-Coated Articles (Serial Designation A 90) of the American Society for Testing Materials.[1] **Uniformity of Coating Test.**

6. The requirements of zinc-coated wire in withstanding the Preece test shall be designated as 1 dip, 2 dip, 3 dip, 4 dip, etc., depending on the number of one-minute immersions in the standard Preece test solution that the coated wire is required to withstand. Fractional dip classes may be used, as 3½ dip, meaning 3 one-minute dips plus 1 half-minute dip. **Dip Designation.**

7. There is a general relation between the weight of zinc coating and the number of dips in copper sulfate which the coating will withstand. Ordinarily a coating of Wt. 8 or heavier will withstand at least four immersions; one of Wt. 6, at least three immersions; one of Wt. 4, at least two immersions. **Zinc Coating-Dip Relation.**

PHYSICAL PROPERTIES OF COATINGS

8. (*a*) Wrap tests of zinc-coated wire, performed to measure adherence of the coating, may be required in some specifications. **Wrap Tests.**

(*b*) When a wrap test is specified, the coating shall be tested by wrapping two turns around a cylindrical mandrel of the diameter specified at a rate of about 15 turns per minute, and a coating shall be considered as meeting the test requirements if, after wrapping, it does not flake and none of the coating can be removed from the wire by rubbing with the bare fingers.

9. The diameters of the test mandrels used shall be approximately even multiples of the diameter of the wire tested. Mandrel sizes shall be designated as mandrel 1, mandrel 5, mandrel 12, etc., depending upon whether the mandrel diameters are 1, 5, 12, etc., times the diameter of the wire to be tested. **Diameter of Mandrels.**

NOTE.—In general, wires carrying coatings of the higher weights and meeting higher dip test requirements are used in the more severe conditions of exposure.

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[1] 1927 Book of A.S.T.M. Standards, Part I.

TENTATIVE METHOD OF TEST
FOR
MAGNETIC PROPERTIES OF IRON AND STEEL AT LOW INDUCTIONS FOR AUDIO AND POWER FREQUENCIES[1]

Serial Designation: A 34 - 27 T

This is a **Tentative Standard,** published for the purpose of eliciting criticism and suggestions, and as such is subject to annual revision.

Issued, 1927.

Properties at Low Inductions and Audio Frequencies

TEST SPECIMENS

Test Specimens. 1. (*a*) Test specimens shall preferably be of the ring form. Ring specimens shall conform to the requirements specified in Sections 2 and 3 of the Standard Methods of Test for Magnetic Properties of Iron and Steel (Serial Designation: A 34) of the American Society for Testing Materials.[2]

(*b*) If mutually agreed upon by the manufacturer and purchaser, the rings may be sheared at one point to facilitate insertion of the specimen into form-wound coils. If this method of preparation is used, the slits shall be staggered so as to come at different points in the magnetic circuit.

(*c*) As an alternative, test specimens of sheet material not exceeding 0.05 cm. (0.0197 in.) in thickness may be of the form described in Section 9 (*a*) of the Standard Methods of Test for Magnetic Properties of Iron and Steel (Serial Designation: A 34)[2] except that the four bundles of strips shall be assembled so that at each corner consecutive layers mutually overlap the butt joints occurring in each single layer.

Insulation of Test Specimens. 2. When testing for core loss, the separate laminations comprising each form of specimen shall be effectively insulated from each other.

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[1] Criticisms of this Tentative Method are solicited and should be directed to Mr. R. L. Sanford, Secretary of Committee A-6 on Magnetic Properties, Chief, Magnetic Section, U. S. Bureau of Standards, Washington, D. C.

This tentative method, when adopted as standard, will be added as method *C* to the present Standard Methods of Test for Magnetic Properties of Iron and Steel (Serial Designation: A 34), 1927 Book of A.S.T.M. Standards, Part I.

[2] 1927 Book of A.S.T.M. Standards, Part I.

APPARATUS

Apparatus. 3. (*a*) The testing apparatus shall consist of a 1000-cycle alternating current power supply, a regulating rheostat, an input transformer, the test winding, an adjustable standard of resistance, an adjustable standard of self-inductance, a suitable null detector, and a voltmeter as specified in Paragraphs (*b*) to (*h*) inclusive, and connected in accordance with the diagram shown in Fig. 1.

Test Winding. (*b*) *Test Winding.*—Continuous ring specimens shall be wound with a toroidal test winding distributed uniformly around the circumference of the ring. If the sheared ring specimen is used, the windings may be applied in sections, provided the sections are of equal numbers of turns and uniformly spaced to cover at least 75 per cent of the mean circumference of the ring. The number of turns should be such that an inductance not less than 0.03 henry nor more than 0.15 henry is obtained. The winding conductor shall not be smaller than No. 28 nor larger than No. 20 A.w.g. Care shall be taken to prevent any electrical contact between turns or to the core. It is recommended that double cotton insulated wire be used. The test winding for the strip form of specimen shall be the secondary winding of the solenoids described in Section 9 (*b*), of the Standard Methods of Test for Magnetic Properties of Iron and Steel (Serial Designation: A 34), care being taken that the primary winding is open circuited during the test.

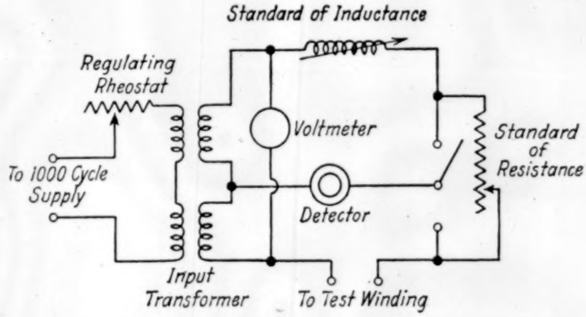

FIG. 1.—Diagram of Connections for Low Induction Alternating Current Test.

Power Supply. (*c*) *Power Supply.*—The supply voltage shall be of approximately a sine wave form, having not more than 10 per cent of total harmonics present.

Transformer. (*d*) *Transformer.*—The input transformer shall have a core formed from magnetic sheet material which is not more than 0.038 cm. (0.015 in.) in thickness and which has a standard low induction permeability of not less than 400.

NOTE.—This corresponds to good quality 4-per-cent silicon steel.

The primary and secondary windings shall have self and mutual inductance characteristics suited to the efficient transmission of power under the test conditions from the source to the test circuit. The secondary winding shall have a tap at its electrical mid-point. The two half-windings so formed shall be closely balanced with respect to each other and with respect to mutual effects to the primary. The degree of balance will be satisfactory if, upon reversal of the complete secondary with respect to the test coils and standards, the readings of the standards are not changed for the new condition of balance by more than 0.02 ohm in resistance or 1 per cent in inductance.

NOTE.—A satisfactory degree of balance can be obtained by winding two conductors together on the core and taking each of the coils thus formed as one-half of the double secondary.

Standard of Resistance.

(*e*) *Standard of Resistance.*—The adjustable standard of resistance shall have a range of from zero to at least 100 ohms, the smallest step being not more than 0.1 ohm. The resistance values for each decade shall be correct to within ±(0.1 per cent + 0.005 ohm). The effective inductance for any setting shall not exceed 0.0001 henry.

Standard of Inductance.

(*f*) *Standard of Inductance.*—The adjustable standard of inductance[1] shall have a range of from 0.03 to 0.15 henry and shall be capable of being read to at least 0.0005 henry. It shall be wound with a stranded conductor, each strand of which shall not be larger than No. 35 A.w.g. and insulated from all other strands. The direct-current resistance shall not exceed 50 ohms. The inductance values shall be accurate to within ±(0.5 per cent + 0.00025 henry).

Detector.

(*g*) *Detector.*—Any zero-current detector having the desired sensitivity may be used. A telephone receiver having an impedance between 300 and 500 ohms at a frequency of 1000 cycles is recommended.

Voltmeter.

(*h*) *Voltmeter.*—Any voltmeter capable of reading the secondary voltage at the test frequency with an accuracy of at least ± 2 per cent may be used. A vacuum thermocouple type having a full scale of 10 volts is recommended.

PROCEDURE

Procedure.

4. (*a*) The test specimen shall be thoroughly demagnetized before testing.

(*b*) The apparatus having been connected in circuit as shown in Fig. 1, the standard of resistance shall be set at zero and the standard of inductance at approximately mid-scale. The secondary voltage of the transformer shall then be adjusted by means of the regulating rheostat to give approximately the standard induction in the test specimen.

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[1] A general form of construction suitable for this instrument is described in U. S. Bureau of Standards *Scientific Paper No. 290*, October 12, 1926.

NOTE.—In this and any other voltage determination the following relation between the secondary voltage and induction in the test specimen shall be used:

$$E_s = 4.44 fNAB \times 10^{-8}$$

where E_s = the secondary voltage (R.M.S.value);
f = the test frequency in cycles per second;
N = number of turns in the test winding;
A = cross-sectional area of the test specimen in square centimeters;
B = maximum induction in gausses.

The standards of resistance and inductance shall then be alternately adjusted until the detector indicates zero difference of potential between its terminals. The readings of the standards shall be noted and the transformer secondary reversed and a second balance obtained. The mean of the two inductance readings shall be taken as the inductance of the test coil. The resistance readings shall be added to or subtracted from the resistance of the standard inductance, as indicated by the connection, and the mean of these resultants taken as the effective resistance of the test coil. Subtracting from this value the direct current resistance of the test winding gives the effective resistance due to the core loss in the test specimen.

CALCULATIONS

Low Induction Permeability.

5. (*a*) *Permeability.*—The standard low induction permeability shall be calculated from the inductance value of the test coil determined as described in Section 4 (*b*) by means of the following formulas:

(1) For Ring Specimens:

$$\mu_{X/1000} = \frac{L \times 10^9}{2 N^2 h \log_e \frac{D}{d}}$$

where $\mu_{X/1000}$ = standard low induction permeability (permeability at 10 gausses and 1000 cycles);
L = inductance of the test coil in henrys;
N = number of turns in the test winding;
h = net axial height of the core in centimeters (see Note);
D = outer diameter of the core;
d = inner diameter of the core.

NOTE.—The net axial height of the core shall be determined from measured values of the diameters and weight and standard values of density.

(2) For Straight Strip Specimens:

$$\mu_{X/1000} = \frac{41{,}600\,L}{A}$$

where A = cross-sectional area of the test specimen in square centimeters.

Low Induction Core Loss.

(*b*) *Core Loss.*—The standard low induction core loss shall be calculated from the measured effective resistance due to the core loss in the test specimen determined in Section 4 (*b*) by means of the following formula:

$$W_{X/1000} = \frac{R_1\,E^2{}_s \times 10^3}{4\,\pi^2 f^2 l^2\,M}$$

where W X/1000 = the standard low induction core loss in watts per kilogram;
R_1 = the effective resistance due to the core loss of the test specimen;
M = weight of the test specimen in grams;
E_s = the secondary voltage (R.M.S. value) (see Section 4 (*b*));
f = the test frequency in cycles per second;
L = the inductance of the test coil in henrys.

TENTATIVE DEFINITIONS OF TERMS RELATING TO HEAT TREATMENT OPERATIONS (ESPECIALLY AS RELATED TO FERROUS ALLOYS)[1]

Serial Designation: A 119 - 27 T

This is a **Tentative Standard,** published for the purpose of eliciting criticism and suggestions, and as such is subject to annual revision.

ISSUED, 1927

In preparing the definitions included herein, the terms have been so defined, as most in keeping with present day usage, that they shall mean definite operations and shall not be considered as referring to the resultant structures or general conditions.

By "critical temperature range," as used in the definitions, is meant that temperature range illustrated by the following Fig. 1, taken from Howe:

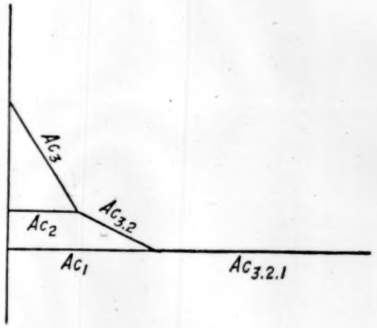

FIG. 1.

Heat Treatment.—An operation or combination of operations involving the heating and cooling of a metal or an alloy in the solid state.

NOTE.—This is for the purpose of obtaining certain desirable conditions or properties. Heating and cooling for the sole purpose of mechanical working are excluded from the meaning of this definition.

Quenching.—Immersing to cool.

NOTE.—Immersion may be in liquids, gases or solids.

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[1] Criticisms of these Tentative Definitions are solicited and should be directed to Mr. J. H. Hall, Secretary of Committee A-4 on Heat Treatment of Iron and Steel, Taylor-Wharton Iron and Steel Co., High Bridge, N. J.

Hardening.—Heating and quenching certain iron-base alloys from a temperature either within or above the critical temperature range.

Annealing.—Annealing is a heating and cooling operation of a material in the solid state.

NOTE 1.—Annealing usually implies a relatively slow cooling.

NOTE 2.—Annealing is a comprehensive term. The purpose of such a heat treatment may be:

(*a*) To remove stresses
(*b*) To induce softness
(*c*) To alter ductility, toughness, electrical, magnetic or other physical properties
(*d*) To refine the crystallin structure
(*e*) To remove gases

In annealing, the temperature of the operation and the rate of cooling depend upon the material being heat treated and the *purpose* of the treatment.

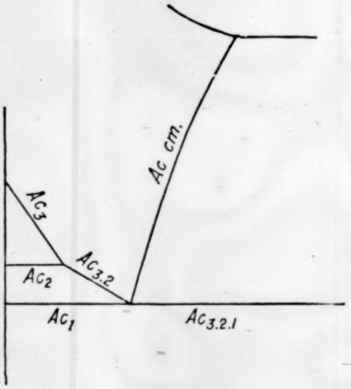

FIG. 2.

Certain specific heat treatments coming under the comprehensive term "annealing" are:

Normalizing.—Heating iron-base alloys above the critical temperature range followed by cooling to below that range in still air at ordinary temperature.

NOTE.—In the case of hyper-eutectoid steel, it is often desirable to heat above the Ac_{cm} line, as shown in Fig. 2.

Spheroidizing.—Prolonged heating of iron-base alloys at a temperature in the neighborhood of, but generally slightly below, the critical temperature range, usually followed by relatively slow cooling.

NOTE 1.—In the case of small objects of high-carbon steels, the spheroidizing result is achieved more rapidly by prolonged heating to temperatures alternately within and slightly below the critical temperature range.

NOTE 2.—The object of this heat treatment is to produce a globular condition of the carbide.

Tempering (*also termed Drawing*).—Reheating after hardening, to some temperature below the critical temperature range followed by any rate of cooling.

NOTE 1.—Although the terms "tempering" and "drawing" are practically synonymous as used in commercial practice, the term "tempering" is preferred.

NOTE 2.—Tempering meaning the operation of hardening followed by reheating is a usage which is illogical and confusing in the present state of the art of heat treating and should be discouraged.

Malleablizing.—Malleablizing is a type of annealing operation with slow cooling whereby combined carbon in white cast iron is transformed to temper carbon and in some cases the carbon is entirely removed from the iron.

NOTE.—Temper carbon is free carbon in the form of rounded nodules made up of an aggregate of minute crystals.

Graphitizing.—Graphitizing is a type of annealing of cast iron whereby some or all of the combined carbon is transformed to free or uncombined carbon.

Carburizing (*Cementation*).—Adding carbon to iron-base alloys by heating the metal below its melting point in contact with carbonaceous material.

NOTE.—The term "carbonizing" used in this sense is undesirable and its use should be discouraged.

Case Hardening.—Carburizing and subsequently hardening by suitable heat treatment, all or part of the surface portions of a piece of iron-base alloy.

Case.—That portion of a carburized iron-base alloy article in which the carbon content has been substantially increased.

Core.—That portion of a carburized iron-base alloy article in which the carbon content has not been substantially increased.

NOTE.—The terms "case" and "core" apply both to carburizing and case-hardening.

Cyaniding.—Surface hardening of an iron-base alloy article or portion of it by heating at a suitable temperature in contact with a cyanide salt, followed by quenching.

TENTATIVE SPECIFICATIONS
FOR
BRAZING SOLDER[1]

Serial Designation: B 64 – 27 T

This is a **Tentative Standard,** published for the purpose of eliciting criticism and suggestions, and as such is subject to annual revision.

ISSUED, 1927.

Scope. 1. These specifications cover two grades of granular brazing solder, in three classifications: "Round Grain," "Long Grain," and "Lump," as described in Sections 6, 7, and 8, respectively.

MANUFACTURE

Process. 2. These solders shall be produced by grinding or other process of granulation.

CHEMICAL PROPERTIES AND TESTS

Chemical Composition. 3. The material shall conform to the following requirements as to chemical composition:

	50–50 GRADE	52–48 GRADE
Copper, per cent	50.00 – 53.00	52.00 – 55.00
Lead, maximum, per cent	0.50	0.50
Iron, maximum, per cent	0.10	0.10
Zinc, per cent	remainder	remainder

Chemical Analysis. 4. A composite sample of not less than 2 oz. shall be taken from each 2000 lb. or fraction thereof in the shipment by taking, as nearly as possible, equal parts from each package or container. Samples shall consist of the grains as prepared for round grain, and long grain solder, or, in the case of lump solder of material obtained by drilling, milling or sawing the lumps. The samples shall be clean and free from oil, dirt, oxide or other foreign material.

5. In the case of dissatisfaction, the solder shall be sampled in the presence of representatives of both the seller and the purchaser.

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[1] Criticisms of these Tentative Specifications are solicited and should be directed to Mr. P. D. Merica, Secretary of Committee B-2 on Non-Ferrous Metals and Alloys, International Nickel Co., 67 Wall St., New York City.

The thoroughly mixed sample shall be divided into three equal parts, each of which shall be placed in a sealed package, one for the seller, one for the purchaser, and one for an umpire, if necessary.

CLASSIFICATION AND SIZES

Round Grain Solder.

6. (*a*) Round grain solder shall be furnished according to the following classification and sizes:

Fine Grain

Retained on No. 8 Standard Screen (2.38-mm. opening)	none
Retained on No. 40 Standard Screen (0.42-mm. opening)	not more than 5 per cent
Retained on No. 100 Standard Screen (0.149-mm. opening)	not less than 90 per cent
Passing No. 100 Standard Screen (0.149-mm. opening)	not more than 5 per cent

Coarse Grain

Retained on No. 8 Standard Screen (2.38-mm. opening)	not more than 8 per cent
Retained on No. 40 Standard Screen (0.42-mm. opening)	not less than 90 per cent
Passing No. 40 Standard Screen (0.42-mm. opening)	not more than 2 per cent

(*b*) Mixed round grain solder shall be a mixture of all grains from fine to coarse.

Long Grain Solder.

7. Long grain solder shall be furnished in the following sizes:

(*a*) Fine long grain solder shall consist of fairly uniform grains about $\frac{1}{2}$ in. in length and about $\frac{1}{16}$ in. in maximum diameter.

(*b*) Coarse long grain solder shall consist of irregular aggregates of long grains about $\frac{1}{4}$ in. to 1 in. in length and about $\frac{1}{4}$ in. in maximum diameter.

(*c*) Mixed long grain solder shall be a mixture of all grains from fine to coarse.

Lump Solder.

8. Lump solder shall consist of irregular lumps of long grain solder, about 2 to 4 in. in dimensions.

PACKING AND MARKING

Packing.

9. Round and long grain solder shall be packed in strong wooden boxes, not to exceed 200 lb. per box. The fine grain solders shall be packed in paper-lined wooden boxes. Lots weighing less than 100 lb. shall be packed in tin containers, enclosed in wooden boxes unless otherwise specified.

10. Lump solder shall be packed in strong barrels, not to exceed 500 lb. per barrel.

11. The coarse grain or mixed solders may be packed in strong barrels when so specified.

Marking. 12. Each package shall be legibly marked with the grade and size, the weight of the material, brand or trade mark of the manufacturer, and the contract or purchase order number.

IMPURITIES

13. The brazing solder shall be free from oxide, dirt, or any foreign material which will impair its working qualities.

INSPECTION AND REJECTION

Inspection. 14. The manufacturer shall afford the inspector representing the purchaser, without charge, all reasonable facilities to satisfy himself that the solder is being furnished in accordance with these specifications. All tests and inspection shall be so conducted as not to interfere unnecessarily with the operation of the works.

Rejection. 15. Solder which fails to conform to these specifications will be rejected and the manufacturer shall be notified.

TENTATIVE SPECIFICATIONS

FOR

BRONZE TROLLEY WIRE[1]

Serial Designation: B 9 - 27 T

This is a **Tentative Standard,** published for the purpose of eliciting criticism and suggestions, and as such is subject to annual revision.

ISSUED, 1925; REVISED, 1926, 1927.

MANUFACTURE

Scope. 1. These specifications cover round and grooved bronze trolley wire.

Material. 2. The material used shall be bronze of such nature and composition as to secure by proper treatment the qualities hereinafter specified for the finished wire. The copper used shall be electrolytic or low-resistance lake copper conforming in quality and purity to the requirements of either the Standard Specifications for Electrolytic Copper Wire Bars, Cakes, Slabs, Billets, Ingots and Ingot Bars (Serial Designation: B 5) or of the Standard Specifications for Lake Copper Wire Bars, Cakes, Slabs, Billets, Ingots and Ingot Bars (Serial Designation: B 4) of the American Society for Testing Materials.[2]

Bronze of two qualities may be required:

(*a*) High Strength.

(*b*) Medium Strength.

PHYSICAL PROPERTIES AND TESTS

(*A*) *Round Wire.*

Tensile Strength and Elongation. 3. (*a*) Round wire shall be so drawn that its tensile strength and elongation shall not be less than the values given in Table I

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[1] These specifications were prepared by Committee B-1 on Copper Wire in cooperation with a committee of the American Electric Railway Engineering Association. The specifications of the two organizations are identical.

Criticisms of these Tentative Specifications are solicited and should be directed to Mr. J. A. Capp, Chairman of Committee B-1 on Copper Wire, General Electric Co., Schenectady, N. Y.

These tentative specifications are in effect a revision of the former Standard Specifications for High-Strength Bronze Trolley Wire, Round and Grooved: 40 and 65-per-cent conductivity. The standard specifications, which were last published under the Serial Designation: B 9 - 16, have accordingly been withdrawn.

[2] 1927 Book of A.S.T.M. Standards, Part I.

The elongation shall be determined as the permanent increase in length due to the breaking of the wire in tension measured between bench marks placed upon the wire originally 10 in. apart. The fracture shall be between the bench marks and not closer than 1 in. to either bench mark.

(*b*) Tests upon a section of wire containing a braze shall show at least 95 per cent of the tensile strength of the unbrazed wire.

Elongation tests shall not be made on test sections including brazes.

Twist Test. 4. For the purpose of determining and developing defects which may be prejudicial to the life of trolley wire, owing to its peculiar service, as compared to that of copper wire for other purposes, round wire shall be subjected to the following twisting test. Three twist tests shall be made upon samples 10 in. in length between the holders of the machine. The twisting machine shall be so constructed that there is a linear motion of the tail stock with respect to the head. The twist shall be applied not faster than 10 turns per minute. All three samples shall be twisted to destruction and shall not reveal under test any seams, pits, slivers, or surface imperfections of sufficient magnitude to indicate inherent defects or imperfections in the wire. At the time of fracture the wire shall be twisting with reasonable uniformity. Wire shall not be considered satisfactory which does not withstand, before breaking, at least the number of turns specified below.

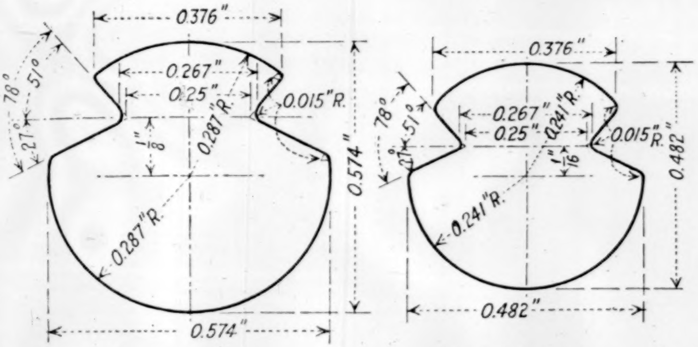
TABLE I.—VALUES FOR TENSILE STRENGTH AND ELONGATION OF ROUND WIRE.

		HIGH-STRENGTH BRONZE WIRE		MEDIUM-STRENGTH BRONZE WIRE	
DIAMETER, IN.	AREA, CIRCULAR MILS	TENSILE STRENGTH, LB. PER SQ. IN.	ELONGATION IN 10 IN., PER CENT	TENSILE STRENGTH, LB. PER SQ. IN.	ELONGATION IN 10 IN. PER CENT
0.548.....	300 000	66 000	4.50	59 000	4.50
0.460.....	211 600	69 000	3.75	61 000	3.75
0.410.....	168 100	71 000	3.25	63 000	3.25
0.365.....	133 225	73 000	2.75	65 000	2.75
0.325.....	105 625	76 000	2.40	68 000	2.40

DIAMETER	NUMBER OF TWISTS
0.548	20
0.460	23
0.410	25
0.365	27
0.325	30

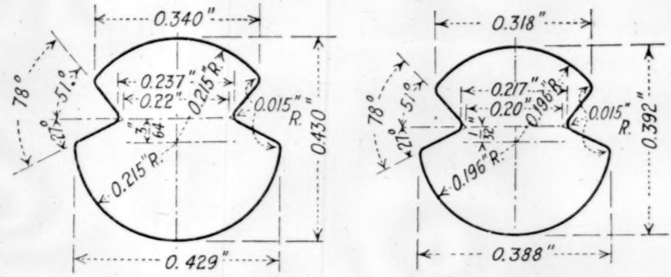
Resistivity. 5. Electric resistivity shall be determined upon fair samples by resistance measurements at a temperature of 20° C. (68° F.).

High-strength wire shall not exceed in resistivity 2188 lb. per mile-ohm. Medium-strength wire shall not exceed in resistivity 1346 lb. per mile-ohm.


0.376"
78°
51°
27°
0.267"
0.25"
0.015"R.
0.287"R.
1/8"
0.574"
0.287"R.
0.574"
0.376"
78°
51°
27°
0.267"
0.25"
0.241"R.
1/16"
0.015"R.
0.482"
0.241"R.
0.482"

Grooved Wire
Nominal Cir Mils, 300 000
Actual Area, 0.2355 sq. in.
Calculated Weight, 4792 lb.
per mile

Grooved Wire
Nominal Cir. Mils, 211 600
Actual Area, 0.1665 sq. in.
Calculated Weight, 3389 lb.
per mile


0.340"
78°
51°
27°
0.237"
0.22"
0.215"R.
3/64"
0.015"R.
0.430"
0.215"R.
0.429"
0.318"
78°
51°
27°
0.217"
0.20"
0.196"R.
1/32"
0.015"R.
0.392"
0.196"R.
0.388"

Grooved Wire
Nominal Cir. Mils, 168 100
Actual Area, 0.1314 sq. in.
Calculated Weight, 2674 lb.
per mile

Grooved Wire
Nominal Cir. Mils, 133 225
Actual Area, 0.1083 sq. in.
Calculated Weight, 2 205 lb
per mile

FIG. 1.

The values given above are based on bronzes of copper-tin compositions and represent classes of such wire formerly referred to as 40-per-cent and 65-per-cent conductivity wire.

Lower resistivities in wires meeting the physical qualifications of these specifications may be obtained by the use of other alloys.

(*B*) *Grooved Wire.*

Physical Properties and Tests.

6. (*a*) The physical tests for grooved wire shall be made in the same manner as those upon round wire. The tensile strength and elongation shall not be less than the values given in Table II. The twist shall be omitted.

(*b*) Tests upon a section of wire containing a braze shall show at least 95 per cent of the tensile strength of the unbrazed wire.

Elongation tests shall not be made on test sections including brazes.

Resistivity.

7. The requirements for resistivity of grooved wire shall be the same as those for round wire of the same nominal cross-sectional area.

TABLE II.—VALUES FOR TENSILE STRENGTH AND ELONGATION OF GROOVED WIRE.

	HIGH-STRENGTH BRONZE WIRE		MEDIUM-STRENGTH BRONZE WIRE	
AREA, CIRCULAR MILS.	TENSILE STRENGTH, LB. PER SQ. IN.	ELONGATION IN 10 IN., PER CENT	TENSILE STRENGTH, LB. PER SQ. IN.	ELONGATION IN 10 IN., PER CENT
300 000	66 000	4.00	59 000	4.00
211 600	69 000	3.25	61 000	3.25
168 100	71 000	2.75	63 000	2.75
133 225	73 000	2.25	65 000	2.25
105 625	76 000	2.00	68 000	2.00

DIMENSIONS AND PERMISSIBLE VARIATIONS

Density.

8. For the purpose of calculating weights, cross-sections, etc., the density of the bronze shall be taken as 8.89 g. per cu. cm. at 20° C. (68° F.).[1]

(*A*) *Round Wire.*

Dimensions and Permissible Variations.

9. (*a*) The size shall be expressed as the diameter of the wire in decimal fractions of an inch, using not more than three places of decimals, *i. e.*, in mils.

(*b*) Wire shall be truly cyclindrical in form. The diameter shall not vary more than 1 per cent over or under the diameter specified.

(*B*) *Grooved Wire.*

Sections.

10. Standard sections of grooved trolley wire shall be those known as the "American Standard Grooved Trolley Wire Sections" (the Standard Design of the American Electric Railway Engineering Association), shown in Fig. 1.

Dimensions and Permissible Variations.

11. (*a*) Size shall be expressed as the nominal area of cross-section in circular mils, the standard sizes being as follows:

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[1] Bronze trolley wire is an alloy as commonly produced of not less than 98 per cent copper with other metals. Determinations of the density of these alloys indicate, as might be expected, an average density practically the same as that found for copper.

Nominal Area, circular mils	Actual Area, sq. in.	Calculated Weight Based on Actual Area, lb. per mile
300 000	0.2355	4792
211 600	0.1665	3389
168 100	0.1314	2674
133 225	0.1083	2205

(*b*) The weight of grooved trolley wire shall not vary more than 4 per cent over or under the weights specified in Paragraph (*a*).

FINISH

Finish.

12. (*a*) The wire shall be of uniform size, shape, and quality throughout, and shall be free from all scale, flaws, splits and scratches not consistent with the best commercial practice.

(*b*) Necessary brazes in trolley wire shall be made in accordance with the best commercial practice.

PACKING

Packing and Shipping.

13. All wire shall be shipped on substantial reels, suitable for the weight of the wire handled, and shall be well protected from injury. If reels are to be lagged, it shall be so specified by the purchaser.

The ends shall be securely fastened to the sides of the reels with no less than six staples. The staples shall be at least 2 in. in length and made from not less than 0.145-in. diameter wire. Care shall be exercised in stapling not to damage the surface of the exposed layer of wire. All reels shall have the arbor holes reinforced with steel plates. Reels shall be marked legibly and indelibly with a serial number, size, kind, length and weight of wire, and such other information as is desired by the purchaser. The length or weight of wire to be wound upon reels shall be agreed upon in placing individual orders.

INSPECTION AND REJECTION

Inspection.

14. All tests governing the acceptance or rejection of the wire, unless otherwise specified, shall be made at the place of manufacture with apparatus furnished by the manufacturer and in the presence of the purchaser, or his representative, who shall be furnished a copy of the tests. Every facility shall be given the purchaser, or his representative, to satisfy him as to the reliability of the results before the wire is delivered. If the purchaser waives inspection, and if he so elects at that time, he shall be furnished with a certified copy of tests made by the manufacturer.

Rejection.

15. Any reel of wire which fails to meet the requirements hereinbefore specified may be rejected. Failure of 30 per cent of the number of reels ready for inspection at one time shall be deemed sufficient cause for the rejection of the whole lot.

TENTATIVE SPECIFICATIONS
FOR
YELLOW BRASS SAND CASTINGS FOR GENERAL PURPOSES[1]

Serial Designation: B 65 – 27 T

This is a **Tentative Standard,** published for the purpose of eliciting criticism and suggestions, and as such is subject to annual revision.

ISSUED, 1927.

Scope. 1. These specifications cover castings made from one of the many yellow brasses commonly used for a wide variety of castings.

MANUFACTURE

Process. 2. (*a*) The alloy may be made by any approved method.

(*b*) The castings shall be of uniform quality.

CHEMICAL PROPERTIES AND TESTS

Chemical Composition. 3. (*a*) The alloy shall conform to the following requirements as to chemical composition:

	DESIRED	MINIMUM	MAXIMUM
Copper, per cent	63.5	62.0	67.0
Tin, per cent	none	none	1.0
Lead, per cent	2.5	1.5	3.5
Zinc, per cent	34.0	remainder	remainder
Iron, per cent	none	....	0.75
Nickel, per cent	none	....	0.25
Phosphorus, per cent	none	....	0.03
Aluminum, per cent	none	....	0.3
Sulfur, per cent	none	....	0.05
Antimony, per cent	none	....	0.15
Total other impurities, per cent	none	....	0.15

(*b*) Where "none" is specified it shall be construed to refer to none as determined on a 10-g. sample.

Chemical Analyses. 4. (*a*) An analysis of each melt may be made at the option of the purchaser and at his own expense.

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[1] Criticisms of these Tentative Specifications are solicited and should be directed to Mr. P. D. Merica, Secretary of Committee B-2 on Non-Ferrous Metals and Alloys, International Nickel Co., 67 Wall St., New York City.

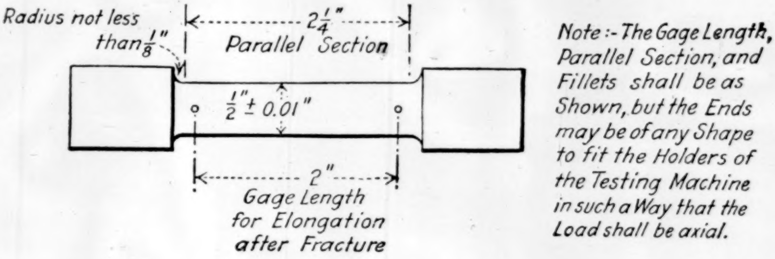
(*b*) The sample for chemical analysis shall be taken from cuttings from the test bars.

PHYSICAL PROPERTIES AND TESTS

Physical Requirements. 5. (*a*) Where desired by the purchaser and so specified in the contract or purchase order, the alloy shall conform to the following requirements as to tensile properties:

Tensile strength, minimum, lb. per sq. in.	20 000
Elongation in 2 in., minimum, per cent	15

(*b*) Where physical requirements are not specified in the contract or purchase order, a fracture of the test specimens shall be made and the fractured surface shall indicate the soundness and uniformity of the metal upon examination with the naked eye. If the test bars do not indicate a uniform soundness and quality of metal, the castings may be rejected.


Radius not less than $\frac{1}{8}$"
$2\frac{1}{4}$"
Parallel Section
$\frac{1}{2}$" ± 0.01"
2"
Gage Length for Elongation after Fracture

Note:- The Gage Length, Parallel Section, and Fillets shall be as Shown, but the Ends may be of any Shape to fit the Holders of the Testing Machine in such a Way that the Load shall be axial.

FIG. 1.—Tension Test Specimen.

Tension Test Specimens. 6. (*a*) The tension test specimen shall be machined from coupons to the dimensions shown in Fig. 1. The ends shall be of a form to fit the holders of the testing machine in such a way that the load shall be axial.

(*b*) The coupon attached to the casting shall be in accordance with the dimensions shown in Fig. 2. The fin gate along the side shall be not less than $\frac{5}{16}$ in. in thickness at any point along its length.

Number of Tests. 7. (*a*) Each casting weighing 250 lb. or more shall have, if practical, at least one test coupon attached. The responsibility of furnishing sufficient test specimens shall rest with the manufacturer.

(*b*) In the case of castings weighing less than 250 lb. each, at least one test coupon shall, if practical, be attached to one or more castings from each melt or heat or from such groups of melts or heats as the purchaser may specify, but in no case shall a lot consist of more than 1000 lb. of castings.

(c) In the case of castings where, in the opinion of the inspector, it is impracticable to attach a test coupon to the casting, bars shall be cast separately in sand. At least one test bar shall be poured from each melt or heat of metal, or such groups of melts or heats as the purchaser may specify, but in no case shall a lot consist of more than 1000 lb. of castings. The bars shall be cast from the first metal poured from the heat and the inspector shall witness the pouring of the test mold.

(d) If any test specimen shows defective machining or reveals casting defects, it may be discarded and replaced by another specimen selected by the inspector. If additional test coupons are not available, the replacement specimen may be taken from the body of a casting selected by the inspector to represent the lot.

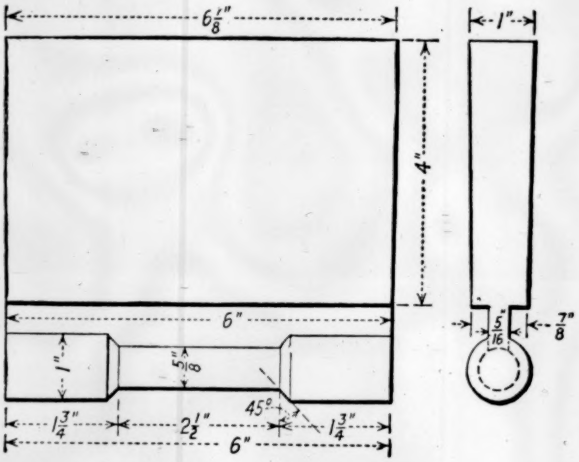


FIG. 2.—Test Specimen Coupon.

WORKMANSHIP AND FINISH

Finish. 8. (a) The castings shall be free from blow holes, porosity, hard spots, shrinkage defects or cracks, or other injurious defects and shall be smooth and well cleaned, before inspection, by sand blasting, tumbling, chipping or other process approved by the inspector.

(b) The castings shall not be repaired, plugged, welded, or "burned-in," unless permission from the inspector has been previously secured. This permission will be given only when the defects are such that after the approved repair the usefulness and strength of the casting has not been impaired. Each such repair shall be encircled by a ring of white paint at the time of shipment.

(*c*) All castings shall be true to pattern, free from swells, etc. Wall thicknesses shall be uniform throughout the lot of castings and all cores shall be accurately set.

(*d*) Where thick and thin sections join, the manufacturer shall be permitted to add (where not previously provided) fillets of proper size to avoid cracking upon cooling, subject to the approval of the inspector.

MARKING

9. The castings shall be marked with pattern or mark number, and when practical with the melt or lot number, at a position on the castings where they will not be machined off in manufacture to finished dimensions. **Marking.**

INSPECTION AND REJECTION

10. (*a*) Inspection may be made at the manufacturer's works or at the point of delivery. Inspection shall be made at the option of the purchaser. **Inspection.**

(*b*) If the purchaser elects to have the inspection made at the manufacturer's works, the inspector representing the purchaser shall have free entry, at all times while work on the contract of the purchaser is being performed, to all parts of the manufacturer's works which concern the manufacture of the material ordered. The manufacturer shall afford the inspector, without charge, all reasonable facilities to satisfy him that the material is being furnished in accordance with these specifications. All tests and inspection shall be so conducted as not to interfere unnecessarily with the operation of the works.

11. Castings which show injurious defects revealed by machining operations subsequent to acceptance may be rejected and if rejected, shall be replaced by the manufacturer without charge to the purchaser. The full weight of the original material rejected shall be returned to the manufacturer. **Rejection.**

TENTATIVE SPECIFICATIONS
FOR
BRONZE CASTINGS IN THE ROUGH FOR LOCOMOTIVE WEARING PARTS[1]

Serial Designation: B 66 – 27 T

This is a **Tentative Standard,** published for the purpose of eliciting criticism and suggestions, and as such is subject to annual revision.

ISSUED, 1927.

Scope. 1. These specifications cover bronze castings in the rough for locomotive wearing parts.

Basis of Purchase. 2. Unless otherwise specified on the purchase order or in the contractural arrangement, the manufacturer shall furnish hard bronze for connecting rod bearings, valve motion bushings, crosshead gibs, and miscellaneous bearings subject to hard wear. Hard bronze shall also be furnished for pedestal wedges and eccentric straps should these appear on the purchase order or contract.

Medium bronze shall be furnished for driving box brasses, engine truck brasses, hub liners, and bearings which require lining metal for facing or lining.

Phosphor bronze and soft bronze will be furnished only when specified.

CHEMICAL PROPERTIES AND TESTS

Chemical Composition. 3. (*a*) The material shall conform to the following requirements as to chemical composition:

Alloy	Lead, per cent	Tin, per cent	Tin and Lead, max., per cent	Zinc, max., per cent	Phosphorus, per cent	Sum of Tin, Lead, Copper, and Phosphorus, min., per cent	Sum of Tin, Lead, Copper, and Zinc, min., per cent	Remainder, max., per cent
Phosphor Bronze..	8 – 11	9 – 11	..	0.5	0.4 – 0.8	99	.....	1.0
Hard Bronze.....	10 – 15	7 – 10	22	1.25	....	..	99.25	0.75
Medium Bronze[a]..	14 – 22	6 – 8	28	1.25	....	..	99.25	0.75
Soft Bronze......	23 – 27	4 – 6	31	0.75	....	..	99.25	0.75

[a] This grade is usually used for chilled castings.

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[1] Criticisms of these Tentative Specifications are solicited and should be directed to Mr. P. D. Merica, Secretary of Committee B-2 on Non-Ferrous Metals and Alloys, International Nickel Co., 67 Wall St., New York City.

These tentative specifications, together with the Tentative Specifications for Car and Tender Journal Bearings, Lined (Serial Designation: B 67 – 27 T), see p. 721, supersede the Tentative Specifications for Non-Ferrous Alloys for Railway Equipment in Ingots, Castings, and Finished Car and Tender Bearings (Serial Designation: B 17 – 21 T), which were accordingly discontinued in 1927.

(*b*) Where no figures are given for impurity maximum, these elements may be present up to any amount to come within the total impurity specified, provided the material otherwise meets the chemical and physical tests. Where maximum percentages are specified, the elements referred to are considered as impurities and shall not be intentionally added.

Chemical Analysis. 4. An analysis shall be made by the purchaser or his representative from one casting representing each lot of 100 castings or fraction thereof. The chemical composition thus determined shall conform to the requirements as specified in Section 3 (*a*) for the particular alloy.

Sample for Chemical Analysis. 5. (*a*) The sample for chemical analysis shall be taken from the casting at three points along the fractured surface, as described in Section 6 (*a*). Drillings through the skin shall be rejected. Equal quantity of drillings from each hole thoroughly mixed shall constitute the sample for chemical analysis.

(*b*) All samples shall be kept free of oil and shall be carefully treated with a magnet to remove any iron introduced in taking the sample.

PHYSICAL PROPERTIES AND TESTS

Physical Inspection. 6. (*a*) The casting representing a lot for acceptance, shall be broken through the center and parallel with the longitudinal axis of the bearing in order to ascertain the uniformity of the grain of the metal. When this fracture shows separation or imperfect mixing of the component parts, or dross or dirt spots, the lot shall be rejected.

Lot. (*b*) One casting may be taken for fracture test from each lot of 100 castings or fraction thereof.

PERMISSIBLE VARIATIONS IN DIMENSIONS

Permissible Variations. 7. The purchaser will furnish drawings showing the dimensions of the castings ordered and permissible variations therefrom, and all castings shall conform to the gages and dimensions shown on the drawings.

WORKMANSHIP AND FINISH

Workmanship and Finish. 8. The castings shall be sound, free from blowholes, flaws and shrinkage cracks, and shall show good foundry practice and workmanship.

MARKING

Marking. 9. Each lot of 100 castings or fraction thereof shall bear a serial number, commencing with the numeral one at the beginning of the year and continuing consecutively until the end of the year. All castings shall also have cast on them the manufacturer's initials or trade mark, the pattern number, and such other marks as are shown on the drawings.

INSPECTION AND REJECTION

Inspection. 10. (*a*) The inspector representing the purchaser shall have free entry, at all times while work on the contract of the purchaser is being performed, to all parts of the manufacturer's works which concern the manufacture of the material ordered. The manufacturer shall afford the inspector, without charge, all reasonable facilities to satisfy him that the material is being furnished in accordance with these specifications. All tests and inspection shall be so conducted as not to interfere unnecessarily with the operation of the works.

(*b*) The purchaser may make the analysis of the material at his own laboratory or elsewhere. Such tests shall show the material to conform to Sections 3, 4, 5, and 6.

Rejection. 11. (*a*) Material which, subsequent to the above tests at the foundry or elsewhere, and its acceptance, shows any defects shall be rejected and shall be replaced at the expense of the manufacturer.

(*b*) Failure to meet the chemical or physical requirements or non-conformity to any of the requirements as to permissible variations, dimensions and markings, constitute sufficient cause for rejection of the lot represented by the sample chosen.

Rehearing. 12. Samples tested in accordance with Section 10 (*b*) which represent rejected material, shall be preserved for 14 days from the date of the test report. In case of dissatisfaction with the results of the tests, the manufacturer may make claim for a rehearing within that time.

TENTATIVE SPECIFICATIONS
FOR
CAR AND TENDER JOURNAL BEARINGS, LINED[1]

Serial Designation: B 67 – 27 T

This is a **Tentative Standard,** published for the purpose of eliciting criticism and suggestions, and as such is subject to annual revision.

ISSUED, 1927.

Scope. 1. These specifications cover journal bearings for use on locomotive tenders, passenger and freight equipment cars.

MANUFACTURE

Manufacture 2. Before lining, the brass backs shall be bored and thoroughly tinned in accordance with the best standard practice.

Basis of Purchase. 3. The thickness of linings which is desired shall be specified in the order. If it is not specified, linings $\frac{1}{4}$ in. thick shall be furnished. After lining, the ends of the bearings shall be made smooth by scraping, filing or machining. They must not be ground or rubbed with abrasive materials.

CHEMICAL PROPERTIES AND TESTS

Chemical Composition of Backing. 4. (*a*) The backing metal shall conform to the following requirements as to chemical composition:

Lead	15 – 22	per cent
Tin	5 – 7	"
Total of tin, lead, and copper, minimum	97	"
Remainder, including zinc, maximum	3	"
Remainder, excluding zinc, maximum	1	"

Within the ranges permitted, the tin and lead shall vary, if at all, in opposite directions, the tin being increased for the lower percentages of lead.

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[1] Criticisms of these Tentative Specifications are solicited and should be directed to Mr. P. D. Merica, Secretary of Committee B-2 on Non-Ferrous Metals and Alloys, International Nickel Co., 67 Wall St., New York City.

These tentative specifications, together with the Tentative Specifications for Bronze Castings in the Rough for Locomotive Wearing Parts (Serial Designation: B 66 – 27 T), see p. 718, supersede the Tentative Specifications for Non-Ferrous Alloys for Railway Equipment in Ingots, Castings, and Finished Car and Tender Bearings (Serial Designation: B 17 – 21 T), which were accordingly discontinued in 1927.

Chemical Composition of Lining.

(*b*) The lining shall conform to the following requirements as to chemical composition:

Tin	As specified	
Antimony, minimum	8	per cent
Tin and antimony	10 – 14	"
Arsenic, maximum	0.2	"
Copper, maximum	0.5	"
Sum of tin, antimony, lead, and arsenic, minimum	99.25	"
Remainder, maximum	0.75	"

NOTE.—In the absence of requirements as to tin content, the manufacturer may use any alloy containing not less than 10 per cent antimony and otherwise meeting the above requirements.

Samples for Chemical Analyses.

5. (*a*) The sample for chemical analysis of the back shall consist of a thorough mixture of equal quantities of fine drillings taken at three points on the bearing, surface metal being discarded.

The sample for chemical analysis of the lining shall be taken by scraping the lining, after removing surface metal.

(*b*) All samples shall be kept free of oil and shall be carefully treated with a magnet to remove any iron introduced in taking the sample.

PHYSICAL INSPECTION AND TESTS

Physical Inspection.

6. The finished bearing representing a lot for acceptance shall be broken, either longitudinally or transversely, or both, in order to ascertain the uniformity of the grain of the metal. When this fracture shows separation or imperfect mixing of the component parts or dross or dirt spots, the lot shall be rejected. This test shall be made before linings are applied. A second test shall be made after application of the lining as follows:

(1) The suspended brass when tapped with a hammer shall give a distinct ring.

(2) The lining when chipped with a cold chisel shall tear from the soldered surface as distinguished from clean shearing.

Lot.

7. Unless otherwise specified, each 300 bearings or fraction thereof from each pattern shall constitute a lot.

The manufacturer shall furnish, without charge, one bearing representing each lot for purpose of tests as specified in Sections 5 and 6.

PERMISSIBLE VARIATIONS IN DIMENSIONS

Permissible Variations.

8. (*a*) The purchaser shall furnish drawings showing the dimensions of the bearings ordered and permissible variations therefrom,

and the bearings shall conform to these drawings within such permissible variations.

(*b*) The thickness at the center of the brass and of the complete bearing shall not vary more than $\frac{1}{32}$ in. over or under the normal thickness shown on the drawing. The thickness of the lining shall not vary more than $\frac{1}{32}$ in. over or under the normal thickness shown on the drawing.

WORKMANSHIP AND FINISH

Finish.

9. (*a*) The bearings shall be sound and free from blow-holes, dross and mechanical defects.

(*b*) All bearing surfaces, including ends, before and after lining, shall be smooth finished, and free from sand. They shall be bored to a true radius, and with the axis parallel to the plane of the top and perpendicular to the side lugs and bearing flange. The lettering shall be clear and distinct. No emery shall be used on either the brass or the lining.

MARKING

Marking.

10. (*a*) Each lot of 300 bearings or fraction thereof shall bear a serial number, commencing with number one at the beginning of the year and continuing consecutively until the end of the year, at each manufacturer's plant.

(*b*) The name or initials of the manufacturer, the initials of the purchaser, journal size, pattern number, year cast, and lot number shall be legibly cast with raised figures on a depressed surface of each bearing, as shown on the drawings.

INSPECTION AND REJECTION

Inspection.

11. (*a*) The inspector representing the purchaser shall have free entry, at all times while work on the contract of the purchaser is being performed, to all parts of the manufacturer's works which concern the manufacture of the material ordered. The manufacturer shall afford the inspector, without charge, all reasonable facilities to satisfy him that the material is being furnished in accordance with these specifications. All tests and inspection shall be so conducted as not to interfere unnecessarily with the operation of the works.

(*b*) The purchaser may make the analysis of the material at his own laboratory or elsewhere. Such tests shall show the material to conform to the requirements of Sections 3, 4, 5, and 6.

Rejection.

12. Failure to meet the chemical or physical requirements, or non-conformity to any of the requirements as to permissible varia-

tions, dimensions and markings, constitute sufficient cause for rejection of the lot represented by the sample chosen.

Rehearing. 13. Samples tested in accordance with Section 11 (*b*) which represent rejected material, shall be preserved for 14 days from the date of the test report. In case of dissatisfaction with the results of the tests, the manufacturer may make claim for a rehearing within that time.

TENTATIVE SPECIFICATIONS
FOR
COPPER TUBING FOR REFRIGERATORS[1]

Serial Designation: B 68 – 27 T

This is a **Tentative Standard,** published for the purpose of eliciting criticism and suggestions, and as such is subject to annual revision.

ISSUED, 1927.

1. These specifications cover annealed copper tubing suitable for use in refrigerators. **Scope.**

MANUFACTURE

2. The tubing shall be made from copper that has been de-oxidized by means of phosphorus. **Process.**

3. The tubing shall be bright annealed after the last drawing operation or after the coiling, if coiling is required.

4. The tubing shall be thoroughly recrystallized and have an average grain size not exceeding 0.040 mm. in diameter.

CHEMICAL PROPERTIES AND TESTS

5. The material shall conform to the following requirements as to chemical composition: **Chemical Composition.**

Copper, minimum	99.85 per cent
Phosphorus, maximum	0.15 "

6. The sample for chemical analysis shall consist of drillings, millings or clippings, taken from each lot of 5000 lb. or fraction thereof, and shall be divided into three equal parts, each of which shall be placed in a sealed package, one for the seller, one for the purchaser, and one for an umpire, if necessary. **Sampling.**

PHYSICAL PROPERTIES AND TESTS

7. (*a*) The material shall conform to the following minimum requirements as to tensile properties: **Physical Properties.**

Tensile Strength, lb. per sq. in.	30 000
Elongation in 2 in., per cent	40

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[1] Criticisms of these Tentative Specifications are solicited and should be directed to Mr. P. D. Merica, Secretary of Committee B-2 on Non-Ferrous Metals and Alloys, International Nickel Co., 67 Wall St., New York City.

(*b*) Five test specimens shall be selected for physical test from each lot of 5000 lb. or fraction thereof.

PERMISSIBLE VARIATIONS IN DIMENSIONS

Dimensional Variations. 8. The inside and outside diameters and the wall thickness of the tubing shall not vary more than the following amounts from that specified:

INSIDE AND OUTSIDE DIAMETERS, IN.	PERMISSIBLE VARIATIONS, IN.	WALL THICKNESS, IN.	PERMISSIBLE VARIATIONS, IN.
Up to $\frac{1}{2}$ incl.	±0.002	Up to $\frac{1}{64}$ incl.	±0.001
Over $\frac{1}{2}$ to $\frac{3}{4}$ incl.	±0.0025	Over $\frac{1}{64}$ to $\frac{1}{32}$ incl.	±0.002
Over $\frac{3}{4}$ to 1 incl.	±0.003	Over $\frac{1}{32}$ to $\frac{1}{16}$ incl.	±0.003
Over 1 to $1\frac{1}{4}$ incl.	±0.0035	Over $\frac{1}{16}$ to $\frac{1}{8}$ incl.	±0.006
Over $1\frac{1}{4}$ to $1\frac{1}{2}$ incl.	±0.004	Over $\frac{1}{8}$ to $\frac{1}{4}$ incl.	±0.0125
Over $1\frac{1}{2}$ to $1\frac{3}{4}$ incl.	±0.0045	Over $\frac{1}{4}$ to $\frac{5}{16}$ incl.	±0.0155
Over $1\frac{3}{4}$ to 2 incl.	±0.005	Over $\frac{5}{16}$ to $\frac{3}{8}$ incl.	±0.019
Over 2	±0.0025 × diameter		

No combination of variations on the same tube shall make the thickness of the wall vary from the nominal thickness by more than these amounts.

Lengths. 9. The lengths of the tubing, when measured at a temperature of 68° F. (20° C.) shall not vary from that specified on the purchase order by more than the following amounts:

ORDERED LENGTH, FT.	PERMISSIBLE VARIATIONS, IN.	
	MINUS	PLUS
Up to 10 inclusive	0	$\frac{1}{8}$
Over 10 to 70 inclusive	0	6

WORKMANSHIP AND FINISH

Workmanship and Finish. 10. The finished tubing shall be smooth, free from interior and exterior mechanical imperfections, and shall have a clean, bright appearance.

PACKING AND MARKING

Packing. 11. The tubing shall be packed in such a manner as to prevent damage in ordinary handling and transportation.

Marking. 12. All boxes, bundles, or barrels shall bear the following information: purchase order number, manufacturer's name, size and kind of material, and part number, if any.

REJECTION

Terms of Rejection. 13. Material failing to comply with the above specifications may be rejected and returned for replacement or full credit at the option of the purchaser.

TENTATIVE SPECIFICATIONS

FOR

ROLLED ZINC[1]

Serial Designation: B 69 – 27 T

This is a **Tentative Standard,** published for the purpose of eliciting criticism and suggestions, and as such is subject to annual revision.

ISSUED, 1927.

Scope. 1. These specifications cover three types of commercial rolled zinc, as described in Section 2. It should be understood that the specifications are general. Any closer limitations on permissible variations shall be a matter of agreement between the buyer and seller at the time of purchase.

SPECIFICATIONS

Types. 2. The rolled zinc shall be divided into the following types:

Type A.—Ribbon zinc and sheets or strips cut from ribbon zinc;
Type B.—Sheet zinc or strips cut from sheet zinc;
Type C.—Boiler plate, name plates, tags, etc.

MANUFACTURE

Manufacture. 3. (*a*) Type *A* rolled zinc shall be rolled from a single bar in one continuous direction.

(*b*) Type *B* rolled zinc shall be rolled by the pack rolling method.

(*c*) Type *C* rolled zinc may be rolled either from a single bar or by the pack rolling method.

CLASSIFICATION ACCORDING TO TEMPER

Temper. 4. Rolled zinc of the three types shall be classified according to temper as follows:

Type *A*	Dead soft Soft Half hard Hard
Type *B*	Commercial
Type *C*	No classification

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[1] Criticisms of these Tentative Specifications are solicited and should be directed to Mr. P. D. Merica, Secretary of Committee B-2 on Non-Ferrous Metals and Alloys, 67 Wall Street, New York City.

Method of Temper Classification.

5. The classification of rolled zinc according to temper shall be determined by means of the dynamic ductility test and the temper test described in Sections 18 to 23, inclusive. The requirements for the several types shall be as specified in Sections 6 and **7**.

Type A:

Temper, Type A.

6. The requirements for temper for the several grades of Type *A* rolled zinc shall be as given in Table I.

TABLE I.—REQUIREMENTS FOR TEMPER, TYPE A ROLLED ZINC.

American Zinc Gage	Thickness, in.	Dead Soft		Soft		Half Hard		Hard	
		Dynamic Ductility, min.	Temper, max.	Dynamic Ductility, min.	Temper, max.	Dynamic Ductility, min.	Temper, max.	Dynamic Ductility, min.	Temper, max.
3........	0.006	0.275	70	0.255	76	0.215	80	0.165	86
4........	0.008	0.280	65	0.260	72	0.220	75	0.170	83
5........	0.010	0.285	60	0.265	66	0.225	70	0.175	80
6........	0.012	0.290	55½	0.270	62	0.230	65	0.180	77
7........	0.014	0.295	52	0.275	58	0.235	61	0.185	74
8........	0.016	0.300	48½	0.280	54	0.240	58	0.190	72
9........	0.018	0.305	46	0.285	51	0.245	54	0.195	69
10........	0.020	0.310	43½	0.290	48	0.250	51	0.200	68
....	0.022	0.315	41½	0.295	45	0.255	48	0.205	65
11........	0.024	0.320	40	0.300	43	0.260	45	0.210	63
....	0.026	0.325	39	0.305	40	0.265	43½	0.215	61
12........	0.028	0.330	37½	0.310	37	0.270	42½	0.220	59
....	0.030	0.335	37	0.315	37	0.275	42	0.225	58
13........	0.032	0.340	36½	0.320	36½	0.280	41	0.230	57
....	0.034	0.345	36	0.324	36	0.285	40½	0.235	56
14........	0.036	0.347	..	0.326	..	0.290	..	0.240	..
....	0.038	0.349	..	0.328	..	0.295	..	0.245	..
15........	0.040	0.350	..	0.329	..	0.300	..	0.250	..
....	0.042	0.352	..	0.330	..	0.300	..	0.250	..
....	0.044	0.353	..	0.331	..	0.305	..	0.255	..
....	0.046	0.354	..	0.332	..	0.305	..	0.255	..
....	0.048	0.355	..	0.333	..	0.310	..	0.260	..
17........	0.050	0.356	..	0.334	..	0.310	..	0.260	..

Type B:

Temper, Type B.

7. The requirements for temper for Type *B* rolled zinc shall be as given in Table II:

PERMISSIBLE VARIATIONS IN DIMENSIONS

(*A*) *Thickness*

Thickness, All Types.

8. The thickness of rolled-zinc plates, sheets and ribbons of Types *A*, *B* and *C*, shall be stated in decimals of an inch.

Type A:

Variations in Thickness, Type A.

9. The permissible variations in thickness of Type *A* rolled zinc shall be as given in Table III. Thicknesses of metals falling between the gages shown shall take the tolerances of the nearest gage.

TABLE II.—REQUIREMENTS FOR TEMPER, TYPE B ROLLED ZINC.

AMERICAN ZINC GAGE	THICKNESS, IN.	COMMERCIAL DYNAMIC DUCTILITY, MIN.	TEMPER, MAX.
3	0.006	0.165	83
4	0.008	0.170	77½
5	0.010	0.175	73
6	0.012	0.180	69
7	0.014	0.185	65
8	0.016	0.190	62
9	0.018	0.195	58½
10	0.020	0.200	57
	0.022	0.205	55½
11	0.024	0.210	54
	0.026	0.215	52½
12	0.028	0.220	51
	0.030	0.225	49
13	0.032	0.230	48
	0.034	0.235	47
14	0.036	0.240	..
	0.038	0.245	..
15	0.040	0.250	..
	0.042	0.250	..
	0.044	0.255	..
	0.046	0.255	..
	0.048	0.260	..
17	0.050	0.260	..

TABLE III.—PERMISSIBLE VARIATIONS IN THICKNESS, IN., PLUS OR MINUS, OF TYPE A ROLLED ZINC.

American Zinc Gage	Thickness, in.	Width			
		0 to 6 in., Inclusive	Over 6 to 9 in., Inclusive	Over 9 to 14 in., Inclusive	Over 14 to 20 in., Inclusive
3	0.006	0.0009	0.0010	0.0011	0.0012
4	0.008	0.0010	0.0011	0.0012	0.0013
5	0.010	0.0011	0.0012	0.0013	0.0014
6	0.012	0.0011	0.0012	0.0013	0.0014
7	0.014	0.0013	0.0014	0.0015	0.0016
8	0.016	0.0014	0.0015	0.0016	0.0017
9	0.018	0.0015	0.0016	0.0017	0.0018
10	0.020	0.0016	0.0017	0.0018	0.0019
11	0.024	0.0018	0.0019	0.0020	0.0021
12	0.028	0.0019	0.0020	0.0021	0.0022
13	0.032	0.0020	0.0021	0.0023	0.0024
14	0.036	0.0021	0.0023	0.0025	0.0026
15	0.040	0.0022	0.0024	0.0026	0.0028
16	0.045	0.0023	0.0025	0.0027	0.0029
17	0.050	0.0024	0.0026	0.0028	0.0030
18	0.055	0.0025	0.0027	0.0025	0.0031
19	0.060	0.0026	0.0028	0.0003	0.0032
20	0.070	0.0027	0.0029	0.0031	0.0033
21	0.080	0.0028	0.0030	0.0032	0.0034
22	0.090	0.0029	0.0031	0.0033	0.0035
23	0.100	0.0030	0.0032	0.0034	0.0036
24	0.125	0.0032	0.0033	0.9003	0.0037

Type B:

Variations in Thickness, Type B.

10. The permissible variations in thickness of Type *B* rolled zinc shall be as given in Table IV. The gage tolerances on sheet zinc is the percentage plus or minus by weight based on the theoretical weight of any gage or size of sheet for each unit of 500 lb. One cubic inch of the material is assumed to weigh 0.2596 lb. No individual sheet shall weigh more than the theoretical weight of a sheet of the gage next above, nor less than a sheet of the gage next below.

TABLE IV.—PERMISSIBLE VARIATIONS IN THICKNESS OF TYPE B, ROLLED ZINC.

American Zinc Gage	Thickness, in.	Variation, Per cent by Weight
3	0.006	±16
4	0.008	±13
5	0.010	±10
6	0.012	± 9
7	0.014	± 8
8	0.016	± 6
9	0.018	± 6
10	0.020	± 6
11	0.024	± 6
12	0.028	± 6
13	0.032	± 6
14	0.036	± 6
15	0.040	± 6
16	0.045	± 6
17	0.050	± 6
18	0.055	± 6
19	0.060	± 6
20	0.070	± 6
21	0.080	± 6
22	0.090	± 6
23	0.100	± 6

Type C:

Variations in Thickness, Type C.

11. The permissible variations in thickness of Type *C* rolled zinc shall be the same as those for either Type *A* or Type *B* rolled zinc, depending upon whether the material is cut from a ribbon or a sheet.

(*B*) *Width*

Variations in Widths, All Types.

12. (*a*) The permissible variations in width for all types of rolled zinc up to 0.100 in. in thickness shall be as follows:

Width, in.	Permissible Variation, in. Plus	Permissible Variation, in. Minus
2 and under	0.010	0
Over 2 to 5, inclusive	0.025	0
Over 5 to 14, inclusive	0.050	0
Over 14	0.125	0

(*b*) The permissible variations in width for all types of rolled zinc from 0.100 in. to 0.250 in. in thickness shall be plus or minus $\frac{1}{16}$ in., and from 0.250 in. to 0.500 in. in thickness plus or minus $\frac{1}{8}$ in., and for material over 0.500 in. in thickness plus $\frac{1}{4}$ in.

(*C*) *Length*

Variations in Length.

13. (*a*) Sheets, strips and plates may be ordered to exact length up to 12 ft., in which case a variation in length of plus $\frac{1}{4}$ in. shall be permitted.

(*b*) When sheets, strips and plates are ordered in stock lengths the pieces shall be cut to the nominal or stock length as a maximum. The shortest acceptable lengths, the maximum permissible percentage by weight of short lengths, and the required percentage by weight of stock lengths in any one shipment shall be as follows:

PERMISSIBLE VARIATIONS IN LENGTH OF PLATES, SHEETS, AND STRIPS UP TO 20 IN. IN WIDTH.

Nominal or Stock Length, ft.	Required Percentage by Weight of Stock, Lengths	Maximum Permissible Percentage by Weight of Short Lengths				
		8 to 10 ft.	6 to 8 ft.	4 to 6 ft.	2 to 4 ft.	Under 2 ft.
10	60	40	30	20	10	0
8	70	..	30	20	10	0
6	80	..	..	20	10	0

Coils.

14. When Type *A* rolled zinc is supplied in coils it shall be consistent with good commercial practice and in no case shall a coil consist of more than 4 pieces. No piece shall be less than 10 ft. long.

Bend and Curvature.

15. Type *A* rolled zinc in lengths over 10 ft. shall not exhibit sidewise bend or curvature in excess of 1 in. in any length of 10 ft.

PACKING AND MARKING

Packing.

16. (*a*) All material shall be properly separated according to size when loaded for shipment. In the case of shipments of plates, sheets and ribbons packed in boxes or crates, the containers shall be sufficiently strong to protect them from injury and loss during shipment.

(*b*) Bulk shipments shall be properly braced in the car.

Marking.

17. Each bundle, box or crate shall be legibly marked with the type letter, dimensions and gross, tare and net weight.

METHODS OF TEST

SAMPLING

Method of Sampling.

18. For purposes of test in shipments of type *A* or *B* rolled zinc, 10 samples shall be taken for every 5000 lb. These samples shall be taken from representative coils or sheets throughout the shipment,

and not more than one sample shall be taken from the same coil or sheet. Test specimens shall be cut from the samples as described in the various test methods.

DYNAMIC DUCTILITY TEST

Apparatus. 19. The dynamic ductility machine for conducting the dynamic ductility test is a modified inclinable power press fitted with an adjustable die as shown in Fig. 1. The speed of the machine shall be 85 to 90 oscillations of the plunger per minute.

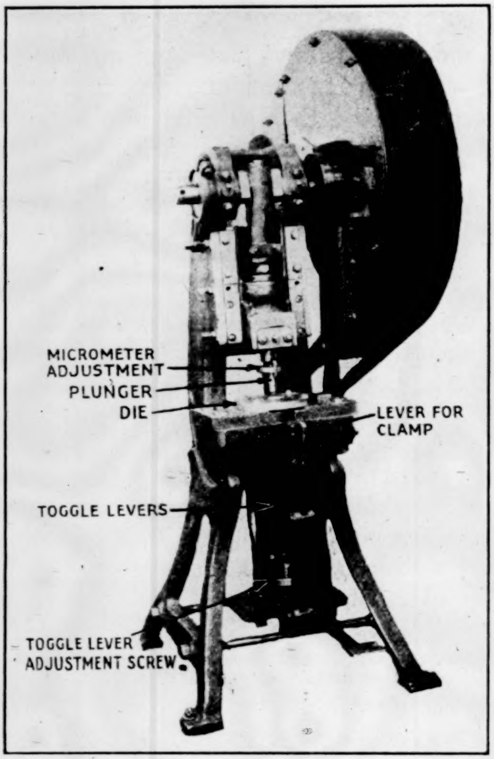
MICROMETER ADJUSTMENT
PLUNGER
DIE
LEVER FOR CLAMP
TOGGLE LEVERS
TOGGLE LEVER ADJUSTMENT SCREW

FIG. 1.—Dynamic Ductility Test Machine.

Test Specimen. 20. (*a*) The test specimen shall consist of a strip cut across the full width of a ribbon or sheet, the width of the strip being approximately 3½ in. When this results in a specimen of less than 12 in. in length, as from narrow unslit ribbon zinc, two specimens 3½ in. in width shall be cut.

(*b*) Test specimens from narrow strips such as ribbon or sheet zinc after slitting shall be cut to 20-in. lengths.

NOTE.—The construction of the machine will not permit test specimens of greater thickness than 0.060 in.

21. (*a*) The temperature of the test specimens, testing machine and room throughout the test shall be kept within 70 and 90° F. **Procedure.**

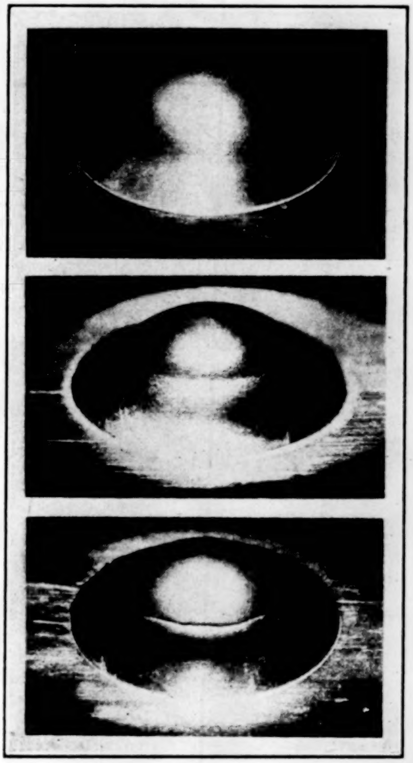

FIG. 2.—Showing Typical Cups Formed in Ductility Test.

The specimen shall be inserted in the machine and firmly clamped. The testing shall be started at one end and the strip moved with each successive cup. The series of cups shall be along the middle line of a 3½ in. strip so that clamping will be uniform around the cup as it is formed. With the motor running the clutch shall be thrown in, lowering the plunger, which, with the die in the clamp base, presses the cup in the test strip. If the cup does not show rupture, the plunger is advanced by increments of 0.005 in. and the cupping repeated with each increased depth until rupture occurs. Having determined the rupturing point additional cups shall be formed as a check. The rupturing point shall not be considered to be that point where an open crack is formed, but where the drawing of the bottom of the cup has just caused "necking" of the surface prior to rupture (See Fig. 2).

NOTE.—An experienced operator should catch the rupture point after two or three trial cups.

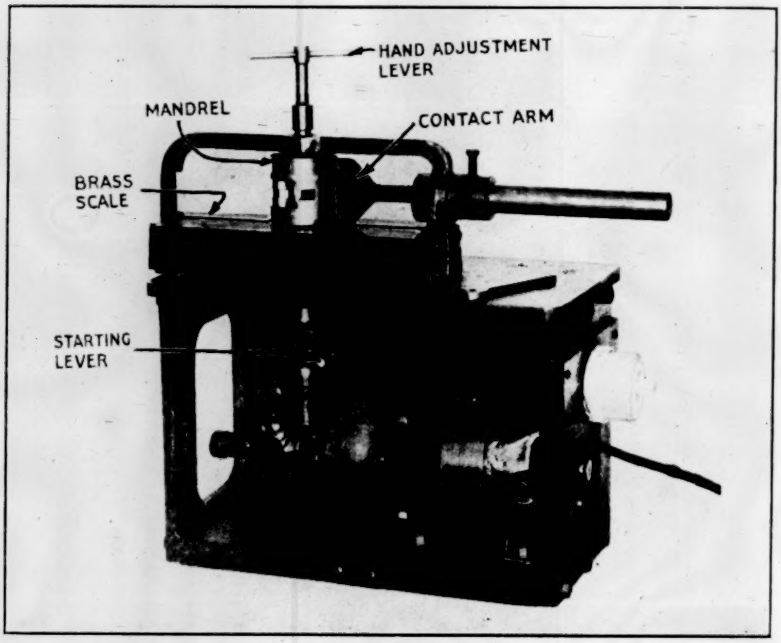

FIG. 3.—Temper Test Machine.

(*b*) The depth of the cup at which rupture just occurs is read from the micrometer attachment on the plunger and is reported as the dynamic ductility of the specimen. The average ductility of the test specimens shall be considered the dynamic ductility of the shipment.

NOTE.—The micrometer attachment on the plunger mechanism measures the distance that the plunger extends beyond the zero point. The zero point is where no impression would be made on the test strip. The clamp base is adjusted for the varying thicknesses. The micrometer attachment also serves to advance and withdraw the plunger.

TEMPER TEST

Apparatus. 22. The apparatus consists of a temper test machine as shown in Fig. 3.

Test Specimens. 23. Duplicate test specimens shall be cut from each sample and shall be rectangular in shape and cut accurately to $1\frac{1}{2}$ in. in width and $4\frac{31}{32}$ in. in length, with the length taken in the direction of rolling. With ribbon zinc the duplicate test specimens shall be cut from adjacent places across the width of a sample.

NOTE.—The construction of the machine does not permit test specimens of greater thickness than 0.035 in.

Procedure. 24. (*a*) The temperature of test specimens, testing machine and room throughout the test shall be kept within 70 and 90° F. The test specimens shall be inserted to the full depth of the vice of the mandrel and securely held by tightening the vice. The diameter of the mandrel is $2\frac{1}{2}$ in. Inserting the test specimen as specified to the full depth of the vice leaves extended a length exactly one-half the circumference of the mandrel. In the rotation of the mandrel the test specimen is pressed by the contact arm against the mandrel. When the outer or free end passes the contact arm it springs out according to its temper. The speed of rotation of the mandrel shall be between 50 and 55 r.p.m. With the motor running the clutch shall be thrown in, rotating the mandrel counter-clockwise. When the outer end of the specimen has passed the contact arm the rotation of the mandrel shall be stopped by throwing out the clutch. The mandrel shall be turned to the 100-per-cent position which is indicated by a mark on the mandrel and the fixed pointer, and the percentage of temper shall be read from the position of the outer end of the specimen on the underlying graduated scale, consisting of a half circle graduated counter-clockwise from 0 to 100 per cent.

(*b*) The duplicate specimen shall be similarly tested and, in order to eliminate the effect of the curvature of the specimens due to coiling, shall be inserted in the vice in the reverse position to that of the first specimen.

That is, if one specimen is inserted and pressed with its curvature toward the mandrel, the duplicate specimen should be inserted with its curvature away from the mandrel.

(*c*) The average of the readings on two test specimens shall be reported as the temper of the material.

TEST FOR SIDEWISE BEND OR CURVATURE

Procedure. 25. The coil shall be supported on a reel at one end of a table and the ribbon drawn along a 10-ft. straight edge, keeping both ends of the straight edge touching the edge of the ribbon. No point on the straight edge shall then be more than 1 in. from the edge of the ribbon.

GAGING

Procedure. 26. Type *A* rolled zinc shall be gaged with a micrometer caliper which has previously been checked with precision blocks. No two measurements along the length of the coil shall be made within 12 in. of each other, nor shall measurements in any one line across the width of the coil be used as a basis of rejection.

TENTATIVE SPECIFICATIONS
FOR
NON-FERROUS INSECT SCREEN CLOTH[1]

Serial Designation: B 50 - 27 T

This is a **Tentative Standard,** published for the purpose of eliciting criticism and suggestions, and as such is subject to annual revision.

ISSUED, 1923; REVISED, 1925, 1927.

Scope. 1. These specifications cover insect screen cloth woven from non-ferrous wire and intended to be used as a protection against insects or other small animals.

MANUFACTURE

Manufacture. 2. There shall be two classes of standard insect screen cloth depending upon the material used as follows:

(*a*) *Class A*, comprising cloth made from copper wire.

(*b*) *Class B*, comprising cloth made from a 90 copper-10 zinc alloy wire.

3. Insect screen cloth shall be manufactured in five weights or sizes of mesh as follows:

14-mesh regular
16-mesh regular
16-mesh heavy
18-mesh regular
22-mesh heavy

4. The same quality and size of wire shall be used for both the warp and filling.

CHEMICAL PROPERTIES

Chemical Requirements. 5. The composition of the wire used for Class A insect screen cloth shall conform to the requirements either of the Standard Specifications for Lake Copper Wire Bars, Cakes, Slabs, Billets, Ingots and Ingot Bars (Serial Designation: B 4), or of the Standard Specifications for Electrolytic Copper Wire Bars, Cakes, Slabs, Billets, Ingots and Ingot Bars (Serial Designation: B 5) of the American Society for Testing Materials.[2]

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[1] Criticisms of these Tentative Specifications are solicited and should be directed to Mr. W. H. Bassett, Secretary of Committee D-14 on Screen Wire Cloth, American Brass Co., Waterbury, Conn.

[2] 1927 Book of A.S.T.M. Standards, Part I.

6. The wire for Class B insect screen cloth shall conform to the following chemical requirements:

Copper	90.00 to 92.00 per cent
Lead, maximum	0.03 per cent
Iron, maximum	0.06 per cent
Zinc	Remainder

PHYSICAL PROPERTIES OF WIRE

7. The physical properties for all classes of screen wire shall be subject to agreement between the producer of the wire and the purchaser.

NOTE.—Wire for weaving insect screen cloth is usually furnished with a drawn temper. The needs of different weavers of wire cloth apparently call for difference in drawn temper and it is consequently at present impossible to give definite physical properties which would be satisfactory to the entire trade. It has, therefore, seemed better to leave this matter to specific agreement between the producers of wire and the manufacturers of wire cloth.

STANDARD SIZES, WEIGHTS, DIMENSIONS, ETC.

Size of Wire. 8. (*a*) The nominal diameter of wires to be used for the various weights of standard insect screen cloth shall be in accordance with the following:

MESH	DIAMETER, IN.
14 regular	0.0119
16 regular	0.0113
16 heavy	0.0150
18 regular	0.0100
22 heavy	0.0150

(*b*) The permissible variation from the nominal diameter of any of the wires specified above shall be ±0.00025 in.

9. The mesh as determined by counting the openings per linear inch for a length of one foot on any samples selected at random shall not vary from the nominal value in the warp, but an average variation of not more than ½ mesh per linear inch shall be permissible in the filling.

10. Insect screen cloth shall be furnished in rolls of approximately 100 linear feet. At least 87.5 per cent of the rolls ordered shall be in one continuous length; the remaining rolls may be in two lengths.

11. The widths of standard insect screen cloth shall be from 18 to 48 in. in multiples of 2 in. The permissible variation in over all width as measured from outside wire to outside wire shall be ±⅛ in.

WORKMANSHIP AND FINISH

12. (*a*) The insect screen cloth shall be free from all imperfections and blemishes not consistent with best commercial practice.

(*b*) Well-made splices in individual wires are permitted at any point in the screen cloth.

INSPECTION

13. (*a*) All testing and inspection, both of individual wires and completed cloth, shall be made at the place of manufacture. Tests on individual wires shall be made on samples taken before weaving and not on wires removed from finished cloth.

(*b*) The manufacturer shall afford the inspector representing the purchaser all reasonable facilities to satisfy him that the material conforms to these specifications.

APPENDIX

The following table giving the weights of various mesh of insect screen cloth is not a part of these specifications, but is appended as a source of information for the purchaser:

MESH	APPROXIMATE WEIGHT PER 100 SQ. FT. OF INSECT SCREEN CLOTH WRAPPED AND LABELED READY FOR SHIPMENT
14 regular	14½ lb.
16 regular	15 "
16 heavy	27¾ "
18 regular	14 "
22 heavy	36 "

TENTATIVE METHODS OF CHEMICAL ANALYSIS
OF
ALUMINUM AND LIGHT ALUMINUM ALLOYS.[1]

Serial Designation: B 40 - 27 T.

This is a **Tentative Standard,** published for the purpose of eliciting criticism and suggestions, and as such is subject to annual revision.

Issued, 1921; Revised, 1923, 1925, 1926, 1927.

The methods of analysis listed under "Analysis of Aluminum" contemplate the analysis of aluminum containing more than 98 per cent aluminum and containing only silicon, titanium, iron, copper, carbon and traces of manganese as impurities.

Unless it is positively known that such elements as tin, antimony, zinc, lead, nickel, magnesium, sodium, nitrogen or oxygen (as aluminum oxide) are absent, the methods listed under the "Analysis of Light Aluminum Alloys" should be employed.

ANALYSIS OF ALUMINUM.

(Not less than 98 per cent Aluminum.)

DETERMINATION OF SILICON AND TITANIUM.

DETERMINATION OF TOTAL SILICON.

Solutions Required.

"Acid Mixture."—1200 cc. of H_2SO_4 (25-per-cent by volume), 600 cc. HCl (sp. gr. 1.20) and 200 cc. HNO_3 (sp. gr. 1.42).

25-per-cent Sulfuric Acid.—Pour 250 cc. of H_2SO_4 (sp. gr. 1.84) into distilled water, and dilute to 1000 cc.

Method.

Dissolve 1 g. of the well-mixed sample in 35 cc. of the acid mixture in a covered flat-bottomed porcelain dish or casserole. When the drillings are completely dissolved, boil the solution to complete expulsion of HNO_3 and HCl and heat until copious fumes of H_2SO_4 have been given off for five minutes. Cool and take up the residue with 10 cc. of 25-per-cent H_2SO_4 and 100 cc. of water. Warm to complete solution of the sulfates and filter on an ashless filter paper. Wash the residue with hot water until free from sulfates and ignite in a platinum crucible. Fuse the residue with 8 to 10 times its weight of Na_2CO_3 and treat the fused mass in a casserole or beaker with 20 cc. of H_2SO_4 (1:3), washing out the crucible. Evaporate the solution until it fumes strongly to separate the SiO_2. Cool, dilute to about 100 cc., boil till the salts are dissolved, filter, wash well, ignite in a platinum crucible and weigh. Treat the ash with HF and a few drops of H_2SO_4 (1:3), carefully evaporate till dry, ignite and again weigh.

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[1] Criticisms of these Tentative Methods are solicited and should be directed to Mr. P. D. Merica, Secretary of Committee B-2 on Non-Ferrous Metals and Alloys, International Nickel Co., 67 Wall St., New York City.

From the difference between the two weights deduct a blank obtained from the reagents and filter. The rest of the loss in weight represents SiO_2 corresponding to the Si in the metal.

$$SiO_2 \times 0.4672 = Si.$$

NOTES.

Blanks should be carried along with all reagents and the proper corrections made.

In routine analysis, fusion of the first H_2SO_4 residue with sodium carbonate and subsequent treatment to the point of treating the ash with HF may be omitted. The first residue may be weighed and treated with HF, etc., as directed for the second H_2SO_4 residue. This, however, should not be done if the material contains much graphitic silicon or if the residue after ignition is dark colored.

Since there may be a slight loss of silicon in the filtrates from the silica filtrations, this amount should be recovered by repeated evaporations of the filtrates, for accurate work.

DETERMINATION OF TITANIUM.

APPARATUS AND SOLUTIONS REQUIRED.

Nessler tubes or some form of colorimeter.

Hydrogen Peroxide U. S. P.—This reagent must be free from HF.

Standard Titanium Solution.—This solution is best prepared and standardized as follows:[1]

"Potassium titanium fluoride, K_2TiF_6, best serves as the starting point for the preparation of the standard solution. A quantity of this is recrystallized from boiling water one or more times, dried, and preserved in a glass-stoppered bottle. Enough of it to make 0.5 to 1 liter of the standard sulfate solution is put into a platinum dish and evaporated several times with strong sulfuric acid without bringing to dryness, till the fluorine is completely expelled. The residue is then taken up with water containing enough sulfuric acid to make at least 5 per cent of the latter when fully diluted. Two 50 to 100-cc. portions of the prepared solution are then further diluted, boiled, and precipitated with ammonia. The precipitates are collected on paper, washed with hot water till free from alkali, ignited moist in the filter, blasted, and weighed. Duplicates should agree almost exactly. From the weights found, the strength of the standard is calculated and the result affixed to the bottle containing it. The stopper of the bottle should be coated with vaseline and the needed quantities of solution should be withdrawn by a pipette, never poured. In a solution so prepared there is not enough alkali sulfate to weaken the color when peroxidized."

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[1] W. F. Hillebrand, "The Analysis of Silicate and Carbonate Rocks," *Bulletin No. 700,* U. S. Geological Survey, p. 157.

METHOD.

See "Determination of Total Silicon."

Fuse the non-volatile residue remaining after the silicon determination in a small amount of $K_2S_2O_7$, take up in a little 5-per-cent H_2SO_4 and add to the filtrates and washings from the silicon determination. Evaporate the solution to approximately 100 cc., and treat with 5 cc. H_2SO_4 (sp. gr. 1.84) and 3 g. of iron-free zinc. Heat until the zinc is nearly dissolved and the reduction of copper is complete. Decant the solution into another beaker, wash the zinc and copper with hot water and continue the evaporation of the solution to approximately 75 cc. Cool and transfer to a 100-cc. Nessler's comparison tube, add 5 cc. of 3-per-cent H_2O_2 and dilute to the 100-cc. mark. In another tube, place 88 cc. H_2O, 5 cc. of H_2SO_4 (sp. gr. 1.84) and cool. Add 5 cc. of 3-per-cent H_2O_2 and then from a burette add the standard titanium solution until the colors match. The volume of the standard solution required multiplied by 100 times its titre represents the percentage of titanium in the sample.

NOTES.

The filtrate and washings from the Silicon Determination should ordinarily be colorless. If light yellow owing to iron, the standard comparison solution should be brought to the same tint with ferric sulfate solution before adding the hydrogen peroxide.

In case the amount of titanium is high the solution may be diluted to a definite volume and aliquot portions taken for the colorimetric test.

DETERMINATION OF IRON

SOLUTIONS REQUIRED

"*Acid Mixture.*"—1200 cc. of H_2SO_4 (25-per-cent by volume). 600 cc. of HCl (sp. gr. 1.20) and 200 cc. of HNO_3 (sp. gr. 1.42).

Tartaric Acid Solution.—Dissolve 20 g. of tartaric acid crystals in 100 cc. of distilled water.

Dilute Ammonium Sulfide Solution.—Add 15 cc. of NH_4OH (sp. gr. 0.90) to 15 cc. of distilled water and saturate with H_2S; then dilute to 200 cc. with distilled water. Use freshly made.

Dilute Sulfuric Acid Solution for Reductor (5-per-cent).—Mix 50 cc. of H_2SO_4 (sp. gr. 1.84) and 1000 cc. of distilled water.

Standard Potassium Permanganate Solution.—Dissolve 1 g. $KMnO_4$ in 1000 cc. of H_2O, and allow to stand for several days in a glass-stoppered bottle in a dark closet. Filter the solution through prepared asbestos and standardize against 0.1000-g. portions of pure sodium oxalate. Each cubic centimeter is equivalent to approximately 0.00177 g. of iron.

METHOD

Dissolve 1 g. of the well-mixed sample in 35 cc. of the acid mixture and proceed as in "Determination of Total Silicon," until the first insoluble residue is ignited. Treat this with a little concentrated HNO_3 and HF to remove the silicon, then evaporate to dryness. Fuse the unvolatilized part with $K_2S_2O_7$, dissolve in a little H_2SO_4 (5-per-cent) and add to the main solution. Saturate this solution with H_2S and filter. To the filtrate add 25 cc. of the tartaric acid solution, and then with constant stirring, add NH_4OH (sp. gr. 0.90), finally drop by drop, until it is in slight excess. Pass in H_2S for a few moments, warm somewhat and allow the solution to stand. Filter and wash the sulfide precipitate thoroughly with a freshly made dilute ammonium sulfide solution, until all tartaric acid is washed out.

Dissolve the sulfide precipitate through the filter paper with warm dilute H_2SO_4 (1:10), washing the paper thoroughly, alternately with hot distilled water and with 5-per-cent H_2SO_4, using in all about 100 cc. Boil until H_2S is expelled and add, while hot, a few drops of concentrated solution of $KMnO_4$ until a distinct pink color persists. Boil again, cool and pass the solution through the reductor. Wash the beaker and reductor with 150 cc. of dilute H_2SO_4 for reductor and then with 100 cc. of distilled water. Titrate with standard $KMnO_4$ solution.

NOTES

Results of titration should be checked with a blank determination made on corresponding amounts of solutions used.

A small quantity of liquid should always be left in the reductor funnel and air should never be allowed to enter the body of the reductor.

For further details of the use of reductor see "The Chemical Analysis of Iron," by A. S. Blair, or "Quantitive Chemical Analysis," by H. P. Talbot.

The effect of tartaric acid is to form complexes with aluminum, vanadium, chromium, titanium, etc., preventing their precipitation as hydroxides.

Where the iron exists in very small quantities, a gravimetric method is preferable. In this case, double precipitation of iron sulfide is necessary to eliminate all aluminum. Dissolve the second sulfide precipitate in warm dilute H_2SO_4 (1:10), boil, and oxidize the iron with H_2O_2. Add 3 to 4 g. of NH_4Cl and then NH_4OH (sp. gr. 0.90) in considerable excess, with stirring. Filter quickly, dry and ignite the precipitate, weighing as ferric oxide. If an accurate determination of iron is desired, it is necessary to correct for the small accumulation of silica by treatment of the ignited precipitate with H_2SO_4. HF.

In adding the few drops of concentrated solution of $KMnO_4$ for oxidation, only a very slight excess is used. There may be precipitated a very slight amount of manganese oxide but this can be disregarded in passing the solution through the reductor.

DETERMINATION OF COPPER BY ELECTROLYTIC METHOD

APPARATUS FOR ELECTROLYSIS

See the "Determination of Copper by the Electrolytic Method" in the Standard Methods of Chemical Analysis of Manganese Bronze (Serial Designation : B 27) of the American Society for Testing Materials.[1]

SOLUTIONS REQUIRED

Sodium Hydroxide Solution.—Dissolve 250 g. of NaOH in distilled water and dilute to 1000 cc.

Nitric Acid (1:1).—Pour 500 cc. of HNO_3 (sp. gr. 1.42) into distilled water and dilute to 1000 cc.

METHOD

Dissolve 10 g. of the sample in a large casserole or beaker with 150 cc. of the NaOH solution. This should be added in small portions as the action is vigorous for a time. After the action slackens, complete solution may be hastened by warming. When no evidence of further reaction can be seen, dilute to about 700 cc. with water at the boiling temperature. Filter through a strong paper and wash.

Dissolve the residue from the paper with 25 cc. of hot HNO_3 (1:1) into a beaker for electrolyzing, and wash the filter thoroughly with hot water. Boil to expel oxides of nitrogen, add 6 to 8 cc. of H_2SO_4 (1:1), dilute to about 150 cc. and electrolyze. Use a weighed sand-blasted cathode and a current of from 3 to 5 amperes at approximately 10 volts. When the solution is colorless and 1 cc. of the solution gives no copper test with H_2S water on a porcelain plate, remove the solution from the electrodes quickly without interrupting the current. Quickly rinse the cathode in distilled water and then dip it in two successive baths of alcohol. Shake off the excess alcohol and ignite the remainder by bringing it to the flame of an alcohol lamp. Keep the cathode moving continually while the alcohol burns. Weigh as metallic copper.

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[1] 1927 Book of A.S.T.M. Standards, Part I.

NOTES

The electrolytic method is preferred for the determination of copper no matter what the percentage.

It is not anticipated that the aluminum will contain tin. In case tin has been found it will be preferable to precipitate with hydrogen sulfide. The sulfides are then to be dissolved, digested in HNO_3 (1 : 1), the metastannic acid filtered off and the electrolysis then carried out.

A staining of the anode indicates the presence of lead or manganese.

Copper, when present in small amounts, may also be determined by potassium cyanide titration. See Standard Methods of Chemical Analysis of Alloys of Lead, Tin, Antimony and Copper (Serial Designation: B 18) of the American Society for Testing Materials.[1]

If the electrolytically deposited copper is not bright in appearance, it should be dissolved from the cathode and redeposited from a sulfuric-nitric acid solution, the operation being carried through in the same way as in the first electrolysis.

DETERMINATION OF MANGANESE.

(a) *Persulfate Method.* (For samples containing under 1.5 per cent of Manganese.)

SOLUTIONS REQUIRED.

"Acid Mixture."—Pour 400 cc. of H_2SO_4 (sp. gr. 1.84) into distilled water, cool and add 400 cc. of HNO_3 (sp. gr. 1.42). Then dilute the mixture with distilled water to a total volume of 2000 cc.

Silver Nitrate.—Dissolve 1.33 g. of $AgNO_3$ in 1000 cc. of distilled water.

Stock Sodium Arsenite Solution.—To 15 g. of arsenious oxide (As_2O_3) in a 300-cc. Erlenmeyer flask, add 45 g. of Na_2CO_3 and 150 cc. of distilled water. Heat the flask and contents on the steam bath until the As_2O_3 is dissolved. Cool the solution, filter and make up to 1000 cc. with distilled water.

Standard Sodium Arsenite Solution.—Mix 200 cc. of the stock sodium arsenite solution with 2500 cc. of distilled water, and standardize by the method described below against a steel or iron of known manganese content. One cubic centimeter of this solution should be equivalent to approximately 0.00050 g. of manganese.

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[1] 1927 Book of A.S.T.M. Standards, Part I.

Ammonium Persulfate.—Dissolve 6 g. of ammonium persulfate in 100 cc. of distilled water. (This solution should be made up as needed as it deteriorates rapidly.)

METHOD.

In a 250-cc. Erlenmeyer flask, dissolve 1 g. of the sample in 30 cc. of acid mixture by warming on a water bath until solution is complete. Boil until oxides of nitrogen are expelled. Dilute to 100 cc. with boiling hot water, remove the flask from the flame, add 20 cc. of $AgNO_3$ solution, and then 30 cc. of the persulfate solution. Let the solution stand on the steam bath until it has developed a full permanganate color and no bubbles can be seen to come off when the flask is given a whirling motion. Cool to below 25° C., and titrate with the standard arsenite solution to the disappearance of the pink color.

NOTES.

Large amounts (above 0.01 g. of manganese per 100 cc. of solution) of permanganic acid are unstable; the method can, however, be used with satisfaction for alloys containing high percentages of manganese by decreasing the size of the sample.

The ammonium persulfate must be tested for its strength. A good grade should contain about 95 per cent of $(NH_4)_2 S_2O_8$; some lots contain no more than 25 per cent of the salt.

If it is desired, larger amounts of the sample can be used and correspondingly greater amounts of $AgNO_3$ and $(NH_4)_2S_2O_8$ (preferably in the form of stronger solutions).

(*b*) *Bismuthate Method.* (For samples containing less than 1.50 per cent manganese.) (Optional.)

SOLUTIONS REQUIRED.

"*Acid Mixture.*"—Pour 400 cc. of H_2SO_4 (sp. gr. 1.84) into distilled water, cool and add 400 cc. of HNO_3 (sp. gr. 1.42). Then dilute the mixture with distilled water to a total volume of 2000 cc.

Nitric Acid (1 : 3).—Pour 250 cc. of HNO_3 (sp. gr. 1.42) into distilled water and dilute to 1000 cc.

Dilute Nitric Acid (3-per-cent).—Pour 30 cc. of HNO_3 (sp. gr. 1.42) into distilled water and dilute to 1000 cc.

Standard Permanganate Solution.—Dissolve 1 g. of $KMnO_4$ in 1000 cc. of distilled water. Allow it to stand for at least one week and then filter through purified asbestos. Standardize against 0.1 g. portions of pure sodium oxalate. One cubic centimeter of this solution should be equal to approximately 0.00035 g. of manganese.

Standard Ferrous Ammonium Sulfate Solution.—Dissolve 12.4 g. of ferrous ammonium sulfate crystals in 950 cc. distilled water, and add 50 cc. of H_2SO_4 (sp. gr. 1.84).

METHOD.

In a 250-cc. Erlenmeyer flask, dissolve 1 g. of the sample in 30 cc. of acid mixture by warming on a water bath until solution is complete.

When solution is complete heat to expel all oxides of nitrogen and cool. Dilute with 50 cc. of HNO_3 (1:3) and add 0.5 g. sodium bismuthate. Heat for a few minutes until the purple color has disappeared with or without the precipitation of manganese dioxide. Add a little ferrous ammonium sulfate solution until the solution becomes clear and boil until the oxides of nitrogen are expelled. Cool, add an excess of sodium bismuthate and agitate for a few minutes. Add 50 cc. of 3-per-cent HNO_3 and filter through an alundum crucible or an asbestos pad. Wash with 50 cc. of 3-per-cent HNO_3. Add from a pipette or a burette 10 to 50 cc. (depending on the amount of permanganic acid) of ferrous ammonium sulfate solution and titrate with the $KMnO_4$ solution.

In exactly the same manner carry through a blank determination using the same amounts of acid mixture, HNO_3 (1:3), and sodium bismuthate as was done with the regular sample. Finally add the exact volume of ferrous ammonium sulfate solution employed and titrate with the $KMnO_4$ solution.

The difference between the volumes required in the two titrations represents the manganese in the sample, and the percentage is found by multiplying this volume by 200 times the manganese titre of the permanganate solution.

NOTES.

Large amounts (above 0.01 g. of manganese per 100 cc. of solution) of permanganic acid are unstable; the method can be used with satisfaction for alloys containing high percentages of manganese by decreasing the size of the sample.

The filtrate from the bismuthate must be perfectly clear, as the least particle of bismuthate carried into the filtrate will vitiate the results.

The solution must be cold at time of filtration and titration.

Instead of employing the method of reducing permanganic acid by means of standardized ferrous ammonium sulfate solution and titrating the excess of the reagent, it is possible to reduce the permanganic acid by standard sodium-arsenite solution. See "Determination of Manganese by the Persulfate Method."

The sodium bismuthate reagent should be tested for manganese and used only if its absence is shown.

ANALYSIS OF LIGHT ALUMINUM ALLOYS

A. ALLOYS CONTAINING ONE PER CENT OR LESS OF SILICON

DETERMINATION OF TOTAL SILICON

Proceed as described under "Determination of Total Silicon" under Analysis of Aluminum.

NOTES

In case $PbSO_4$ is present (as evidenced by a white crystallin precipitate quickly settling after stirring) the filtered residue must be washed free from the sulfate with hot dilute HCl (1 : 3). The final washing must be made with hot water.

If the alloy contains much tin an insoluble compound is apt to form on redissolving the sulfates after the first fuming for SiO_2. To avoid this, thoroughly wet all the salts with H_2SO_4 (sp. gr. 1.84) or HCl instead of dilute acid, before adding water.

DETERMINATION OF IRON

Proceed as described under "Determination of Iron" under Analysis of Aluminum.

DETERMINATION OF COPPER BY ELECTROLYTIC METHOD

APPARATUS AND SOLUTIONS REQUIRED

See the "Determination of Copper by Electrolytic Method" under Analysis of Aluminum.

METHOD

For copper contents up to 1 per cent proceed as described under "Determination of Copper by Electrolytic Method" under Analysis of Aluminum.

If the copper content is more than 1 per cent, dissolve a 1-g. sample in a medium size beaker with 20 cc. of the NaOH solution, warming after the reaction slackens. When no further action can be seen, dilute to 200 cc. with hot water, filter and wash with hot water.

Dissolve the metallic residue from the paper into an electrolytic beaker with 10 cc. of hot HNO_3 (1:1) followed by thorough washing. Add dilute H_2SO_4 equivalent to 2 cc. of concentrated acid. Dilute to 150 cc. Electrolyze and finish as described under "Determination of Copper by Electrolytic Method" under Analysis of Aluminum.

DETERMINATION OF MANGANESE

SOLUTIONS REQUIRED

See the "Determination of Manganese," Method (*a*) or (*b*), under Analysis of Aluminum.

METHOD

For manganese contents up to 0.2 per cent proceed as described under "Determination of Manganese" under the Analysis of Aluminum.

If the manganese content is more than 0.2 per cent use an 0.2-g. sample and proceed as described under "Determination of Manganese," Method (*a*) or (*b*), under Analysis of Aluminum.

NOTE

If the manganese content is over 2 per cent there is danger of precipitation at the peroxidizing stage. In that case a suitable aliquot of a new solution should be taken for developing the permanganate form.

DETERMINATION OF CALCIUM AND MAGNESIUM

SOLUTIONS REQUIRED

Sodium Hydroxide Solution.—Same as in the "Determination of Copper by Electrolytic Method" under Analysis of Aluminum.

Sodium Carbonate Wash.—Dissolve 1 g. of Na_2CO_3 in 100 cc. of distilled water.

Hydrochloric Acid (1:1).—Mix equal volumes of HCl (sp. gr. 1.19) and distilled water.

Ammonium Sulfide Wash.—Take 10 cc. of NH_4OH (sp. gr. 0.90) dilute to 500 cc., add 10 g. of HN_4Cl and saturate with H_2S.

Bromine Water.—Place 20 to 30 cc. of liquid bromine in a 500-cc. bottle, fill with cold distilled water, and shake thoroughly. Be very careful to avoid contact of the bromine with the skin.

Ammonium Oxalate Solution.—Make a saturated solution by adding $(NH_4)_2C_2O_4$ in excess to distilled water.

Sulfuric Acid (25-per-cent).—See the "Determination of Total Silicon" in Analysis of Aluminum.

Standard Potassium Permanganate.—See the "Determination of Iron" in Analysis of Aluminum.

Microcosmic Salt Solution.—Prepare a clear saturated solution as required.

Ammonium Nitrate Wash.—Mix 80 cc. of HNO_3 (1:1) with 100 cc. of NH_4OH and dilute to 1 liter.

METHOD

Dissolve 2 g. of the sample in 35 cc. of the NaOH solution, add about 0.5 g. of Na_2CO_3. When dissolved, dilute to 250 cc. with hot water, filter, and wash five times with hot sodium carbonate wash. Dissolve the residue from the filter with 40 cc. of hot HCl (1:1) and a few drops of HNO_3, receiving it in a beaker, and wash the filter. Neutralize this solution with NH_4OH and add from 2 to 5 cc. in excess. Pass in H_2S for 2 or 3 minutes. Filter, and wash a few times with an ammonium sulfide wash.

Boil the filtrate vigorously to drive off $(NH_4)_2S$. When sulfur precipitates add a little bromine water and continue boiling until clear and the odor and color of bromine are gone. Add a drop or two of methyl red as indicator to the solution, then NH_4OH carefully till the yellow color appears. Boil for a minute, filter and wash. Add a few drops of NH_4OH, 10 cc. of $(NH_4)_2C_2O_4$ solution and heat near boiling for 30 minutes, keeping ammoniacal. If a precipitate forms, filter through a small, close-textured paper, and wash eight times with small portions of hot water, reserving the filtrate for determining magnesium.

Return the filter to the precipitation beaker, add 130 cc. of hot water and 20 cc. of H_2SO_4 (25-per-cent), then titrate with standard $KMnO_4$ solution. Deduct a determined blank.

The $Na_2C_2O_4$ value of the $KMnO_4$ multiplied by 0.2990 equals the calcium value.

The filtrate from the calcium determination, or the unfiltered solution if clear, is made just acid with HCl, and 20 to 30 cc. of microcosmic salt solution added. Cool, and add NH_4OH drop by drop, stirring vigorously until a crystallin precipitate begins to form. Continue the very slow addition of NH_4OH with stirring until the precipitate no longer forms, and then add one-tenth the volume of NH_4OH (sp. gr. 0.90) and let stand for at least 3 hours. Filter, and wash with a cold ammonium nitrate wash solution. Place in a weighed porcelain or vitreosil crucible and ignite at about 1000° C. until completely white. Weigh as $Mg_2P_2O_7$, and deduct a blank.

$$Mg_2P_2O_7 \times 0.2184 = Mg$$

NOTES

If much Mg is present (over 1 per cent) some of it may be carried down with the sulfides. In that case, dissolve the precipitate with 10 cc. of HCl (1:1), neutralize and add 2 cc. in excess of NH_4OH, precipitate, and filter off the sulfides as before, then combine the filtrates.

If the alloy contains manganese, the ignited phosphate should be dissolved and tested for manganese by the (*a*) Persulfate Method as described in the "Determination of Manganese" in the Analysis of Aluminum, deduction being made for pyrophosphate corresponding to the manganese found.

DETERMINATION OF ZINC

(*a*) *Zinc Oxide Method.* (For samples containing 1 per cent of zinc or less.)

SOLUTIONS REQUIRED

Hydrochloric Acid (1:1).—Mix equal volumes of HCl (sp. gr. 1.19) and distilled water.

Acid Wash Water.—Slowly stir 10 cc. of H_2SO_4 (sp. gr. 1.84) into 1000 cc. of distilled water, and saturate with H_2S.

Formic Acid Mixture.—Treat 200 cc. of formic acid with 30 cc. of NH_4OH (sp. gr. 0.90) and dilute to 1000 cc.

Formic Acid Wash Water.—Mix 25 cc. of formic acid mixture and 1000 cc. of distilled water and saturate with H_2S.

Hydrochloric Acid (1:10).—Mix 100 cc. of concentrated HCl and 1000 cc. of distilled water.

METHOD

Dissolve 2 g. of the sample in a covered 400-cc. beaker in 45 cc. of HCl (1:1) added cautiously, followed by 1 cc. of HNO_3 (sp. gr. 1.42) toward the end of the reaction. Boil to complete the solution and to expel oxides of nitrogen. Dilute to 200 cc., precipitate with H_2S, filter, and wash with acid wash water. Boil thoroughly to expel H_2S.

Cool somewhat, add 10 g. of citric acid, dilute to 300 cc., neutralize with NH_4OH using methyl red as indicator, then add 25 cc. of the formic acid mixture. Heat nearly to boiling, and pass in a rapid stream of H_2S for 15 minutes. Filter through a close-textured paper set with a little of the liquid to be filtered. Refilter the first part if cloudy. Wash five times with the formic acid wash water. Dissolve the ZnS from the filter into the original beaker with hot HCl (1:10), washing thoroughly with hot water. Boil the solution to expel H_2S. Cool, add 1 g. of citric acid and make just alkaline to methyl red with NH_4OH, dilute to 100 cc., heat, and pass in H_2S for 3 minutes. Add 10 cc. of the formic acid mixture and continue the H_2S for 5 minutes more. Filter through a close-textured, ashless paper set with a little of the liquid to be filtered, and wash five times with the formic acid wash water. To avoid creeping of the precipitate do not fill the paper too near to its top, and do not wet the funnel above the paper.

Ignite the paper and precipitate in a weighed porcelain or vitreosil crucible, starting at a dull red heat and finishing at a moderate red. Cool, and weigh as ZnO. Deduct a determined blank.

$$\text{ZnO} \times 0.8034 = \text{Zn}$$

NOTE

By starting the second sulfide precipitation in the alkaline condition adherence of sulfide to the container is avoided.

(*b*) *Ferrocyanide Method:* (For samples containing over 1 per cent of zinc.)

SOLUTIONS REQUIRED

Ferrous Sulfate Indicator.—Dissolve 0.2 g. of $FeSO_4 . (NH_4)_2SO_4 . 6H_2O$ in 50 cc. of distilled water. Prepare fresh, as required.

Standard Potassium Ferrocyanide Solution.—Dissolve approximately 22 g. of $K_4Fe(CN)_6 . 3H_2O$ per liter of distilled water. It is necessary for this solution to contain a small amount of ferricyanide for indicator purposes. If the solution can be allowed to stand for several weeks enough ferricyanide will be formed by oxidation. For immediate use add 0.15 g. of $K_3Fe(CN)_6$ per liter. The ferrocyanide known solution is standardized by titrating solutions containing known amounts of pure zinc, in accordance with the directions for titration given in this method.

METHOD

If the zinc content is between 1 and 3 per cent dissolve 2 g. of the sample in 45 cc. of the HCl. (1:1). If over 3 per cent dissolve 1 g. of the sample in 25 cc. of the HCl. Proceed as in (*a*) Zinc Oxide Method until the first ZnS precipitate has been washed. Return this precipitate on its paper to the original beaker and add 20 cc. of HCl (1:1). When the sulfide has dissolved, filter, and wash with hot water. Boil the solution containing the zinc to expel H_2S, cool, and wash down. Add two drops of methyl red solution (0.1-per-cent), then neutralize with NH_4OH. Make the solution just acid again with HCl and add 3 cc. of concentrated HCl in excess. Dilute to 200 cc. and heat almost to boiling for titration.

Add five drops of the ferrous sulfate indicator then titrate with the standard potassium ferrocyanide solution. Shortly after starting, a blue color appears and obscures the methyl red. When the ferrocyanide has acted on all the zinc, the red tint reappears since the red is stronger than the light green which would otherwise show. Toward the end the standard solution should be added slowly, stirring vigorously after each addition. The end point is reached when an additional drop causes no visible change from blue to red.

DETERMINATION OF NICKEL
BY THE
DIMETHYLGLYOXIME METHOD

SOLUTIONS REQUIRED

Sulfuric Acid (1:1).—Slowly stir 500 cc. of H_2SO_4 (sp. gr. 1.84) into distilled water, cool, and dilute to 1000 cc.

Hydrogen Sulfide Wash Water.—Slowly stir 10 cc. of H_2SO_4 (sp. gr. 1.84) into 1000 cc. of distilled water and saturate with H_2S.

Tartaric Acid Solution (20-per-cent).—Dissolve 20 g. of tartaric acid in distilled water, dilute to 100 cc. and filter if necessary.

Dimethylglyoxime Solution (1-per-cent).—Dissolve 10 g. of dimethylglyoxime in 1000 cc. of alcohol (95-per-cent).

METHOD

Dissolve 1 g. of the sample in 25 cc. of H_2SO_4 (1 : 1) by warming and adding a drop or two of HNO_3 (sp. gr. 1.42) occasionally until solution is complete. After oxides of nitrogen have been expelled by boiling, add 14 cc. of NH_4OH (sp. gr. 0.90) in order to bring down the acidity to approximately 5 cc. of H_2SO_4 (sp. gr. 1.84) per 100 cc. of solution. Treat with H_2S. Filter off the sulfides, wash with hydrogen sulfide wash water and boil the filtrate until H_2S is expelled. Add a few crystals of $(NH_4)_2S_2O_8$ and boil thoroughly to destroy sulfur and oxidize iron. Add 20 cc. of tartaric acid solution and make slightly ammoniacal. If no precipitate appears add HCl (sp. gr. 1.19) to slight acidity. If a precipitate appears, dissolve in HCl, add 10 cc. of tartaric acid and again make ammoniacal, repeating the operation, if necessary, to get a clear solution. To the weakly-acid solution add dimethylglyoxime solution in such an amount that the ratio of the reagent to nickel is at least four to one. Heat the solution to boiling and make slightly ammoniacal. Allow to digest, while cooling, for two hours. Collect on a weighed Gooch crucible and wash thoroughly with hot water. Dry for 45 minutes at from 110 to 120° C. and weigh. The nickel dimethylglyoxime contains 20.32 per cent of nickel.

B. ALLOYS CONTAINING OVER ONE PER CENT OF SILICON

DETERMINATION OF SILICON

Solutions Required

See the "Determination of Total Silicon" under the Analysis of Aluminum.

Method

If the silicon content is under 10 per cent use a 1-g. sample and if a content of higher percentage is expected use an 0.5-g. sample. Place the sample in a 350-cc. casserole. Keeping covered as much as possible, cautiously add 35 cc. of the acid mixture. When no further action can be seen evaporate to dryness, taking care to prevent spattering. Heat to strong fuming of SO_3. Cool, moisten with 10 cc. of H_2SO_4 (25-per-cent), add 100 cc. of hot water, and boil to dissolve the salts. Stir in some ashless paper pulp, then filter through a close-textured paper. Wash three or four times with hot water. Evaporate the filtrate to fumes, cool, dissolve with water, add paper pulp, filter, and wash as before.

Ignite the residues in a large platinum crucible. After cooling, add from 5 to 8 g. (depending on the amount of residue) of Na_2CO_3. Stir well and cover with a layer of Na_2CO_3. Fuse cautiously till nearly quiet, then finish with a full Meker flame or its equivalent. Run the melt up the sides of the crucible, cool, and place in a casserole with 60 to 80 cc. of H_2SO_4 (25-per-cent). When the melt has dissolved remove the crucible, washing it into the casserole. Evaporate, and finally heat till heavy fumes are given off, then remove from the heat. When still moderately warm add a little cold water followed by 100 cc. of hot water. Heat to complete solution of soluble salts, but avoid too long a treatment as the SiO_2 tends to redissolve. Filter the liquid, preferably after stirring in some paper pulp, and wash thoroughly with hot water.

Evaporate the filtrate and heat to fuming again to separate any silica which may have escaped the first treatment. This is collected in the same manner as the main portion.

Dry the filters with contents, then ignite in a platinum crucible, cool, and weigh. Moisten with a few drops of H_2SO_4 (1:3) and add several cubic centimeters of HF. Evaporate until dry, ignite, cool, and weigh again. The loss in weight represents SiO_2. After correcting for a determined blank multiply by 0.4672 to find the amount of Si in the sample taken.

NOTE

In diluting the solution after the fuming which succeeds the fusion, adding a little cold water to the warm solution throws out the silica in a more granular form which is less soluble and more convenient to filter.

DETERMINATION OF IRON

METHOD

Dissolve 1 g. of the sample in the acid mixture and proceed as under "Determination of Total Silicon" under Analysis of Aluminum till the first insoluble residue is ignited. Treat this with a little concentrated HNO_3 and HF to remove the silicon, then evaporate to dryness. Fuse the unvolatilized part with $K_2S_2O_7$, dissolve, and add to the main solution. From this point continue by the sulfide separation method as described under "Determination of Iron" under Analysis of Aluminum.

DETERMINATION OF COPPER

METHOD

Dissolve 5 g. of the sample in a large casserole or beaker by adding, in small portions, 150 cc. of the acid mixture used for starting the silicon determination. When the aluminum is dissolved, evaporate to dryness and heat until copious fumes of H_2SO_4 are given off, cool, dissolve by heating with 300 cc. of water, filter, and wash a few times.

Ignite the dark residue in a platinum dish, add 10 cc. of HNO_3 (sp. gr. 1.42), 2 cc. of H_2SO_4 (1:1), and then add HF drop by drop until the silicon has dissolved. Evaporate to fumes to remove the HF. Take up with water and add to the main filtrate.

Pass H_2S into this liquid for several minutes, and filter off the precipitated CuS, washing with 1-per-cent H_2SO_4 saturated with H_2S. Ignite the precipitate in a porcelain crucible, cool, dissolve by heating with some HNO_3 (1:1), transfer to a suitable beaker and finish electrolytically as under "Determination of Copper by Electrolytic Method" under the Analysis of Aluminum.

DETERMINATION OF MANGANESE

METHOD

Proceed as under "Determination of Manganese," (*a*) Persulfate Method, under the Analysis of Aluminum, except that a few drops of HF should be added to remove the silicon when dissolving the sample. After the solution is complete boil a short time to remove most of the HF, then proceed as usual.

TENTATIVE METHOD OF TEST
FOR
CHANGE OF RESISTANCE WITH TEMPERATURE OF METALLIC MATERIALS FOR ELECTRICAL HEATING[1]

Serial Designation: B 70 – 27 T

This is a **Tentative Standard,** published for the purpose of eliciting criticism and suggestions, and as such is subject to annual revision.

Issued, 1927.

Scope. 1. This method covers the determination of the change of resistance with temperature of metallic materials for electrical heating, and is applicable at temperatures up to 500° C., or higher.

TEST SPECIMEN

Test Specimen. 2. The test specimen shall be prepared in a form suitable for measuring the temperature in an electric-resistance furnace. When the resistance measurement is to be made with a Kelvin double bridge or a potentiometer, the specimens shall be provided with four leads, either integral with or welded to the specimen. When a Kelvin double bridge is used, each lead shall have a resistance not exceeding one-fourth of the resistance of the specimen between the points of attachment of the potential leads. In any case the leads shall be in pairs and located near the ends of the specimen. The distance between the points of attachment of a potential lead and its corresponding current lead shall be less than one-tenth of the length of the specimen between the potential leads. The two outside leads shall be used for current and the two inside ones for potential. When the resistance is to be measured by a Wheatstone bridge, the resistance of the leads shall not exceed 1 per cent of the resistance of the specimen.

Leads. 3. The leads shall be of the same material as that of the test specimen. They shall have a length within the heated zone of the furnace of at least fifty times their minimum transverse dimension, in order to avoid disturbance of the temperature of the specimen by conduction of heat to the colder parts of the furnace.

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[1] Criticisms of this Tentative Method are solicited and should be directed to Mr. F. E. Bash, Secretary of Committee B-4 on Metallic Materials for Electrical Heating, Technical Department, Electrical Alloy Division, Driver-Harris Co., Morristown, N. J.

APPARATUS

Electric Furnace.

4. The furnace for heating the specimen shall be of such a type that the temperature can be controlled over the range from room temperature to the maximum desired. It shall be so constructed that the specimen, or specimens, and the thermocouple, or thermocouples, can be maintained at a uniform and constant temperature at desired points within the working range. The specimen and thermocouples shall be so shielded as to prevent direct radiation from hotter, or to colder, parts of the furnace.

In order to test the uniformity of the temperature in the region to be occupied by the test specimen a typical specimen and thermocouple shall be prepared and mounted in the center of this region. The furnace shall then be heated to its maximum temperature and maintained at this temperature until equilibrium is reached. The specimen shall then be moved in the furnace in the direction of the maximum temperature gradient through a distance equal to the maximum dimension of the largest specimen and thermocouple assembly which is to be used in this furnace. The temperature of the typical specimen in this position shall not differ from that in the normal position by more than 10° C.

MEASUREMENTS

Resistance.

5. The resistance shall be measured with an accuracy of 0.1 per cent. The measuring current shall be so small that the resistance of a specimen is not changed thereby by as much as 0.1 per cent. This condition can be determined experimentally, or it can be computed from the power expended and the surface of the specimen.

Test Current.

6. (*a*) To determine experimentally that the normal test current is not too large, the specimen shall be brought to a temperature where there is a relatively large uniform change of resistance with temperature.

NOTE.—In the case of nickel-chromium alloy 400° C. is a suitable temperature.

The test current shall be applied and maintained until the resistance of the specimen has become constant. The current shall then be increased by 40 per cent and maintained at this value until the resistance of the specimen has again become constant. If the change in resistance is greater than 0.1 per cent, the test current is too large and should be reduced until the foregoing limitations are reached.

(*b*) The test current has a negligible effect on the resistance measurement when the energy liberated by its passage through the specimen is less than 0.01 watt per sq. cm. of the effective free surface of the specimen. For straight specimens and those which are so coiled or bent that the distance between the adjacent convolutions is greater than five times the maximum transverse dimension of the cross-section of the specimen, the free surface shall be considered to be the surface area of the portion of the specimen between the potential leads. When, as for the sake of saving space in the furnace, the specimen is wound into a spiral or helix, or bent back and forth upon itself in such a manner that the distance between adjacent convolutions is less than five times the maximum transverse dimension of the cross-section of the specimen, the free surface shall be considered to be the surface area of the cylindrical or prismatic volume enclosing the coiled or convoluted specimen. The energy loss due to the measuring current shall be calculated from the following formula:

$$W = I^2R_m$$

where W = the energy loss in watts;
I = the measuring current in amperes;
R_m = the resistance in ohms at maximum test temperature.

PROCEDURE

Procedure. 7. The test specimen shall be prepared from material as left by the manufacturing process. The specimen shall be mounted in the furnace and readings made on the cold specimen before the furnace is heated. The furnace shall then be brought to the maximum test temperature for the material and held at this point until the resistance of the specimen remains constant except for the relatively slow changes due to oxidation. The temperature of the furnace shall then be lowered in steps of approximately 200° C. to room temperature. Measurements shall be made at each point when temperature and resistance have become stationary. The time at which each reading is taken shall be noted. Each point shall be defined by the mean of at least one pair of resistance readings for which the current through the sample has been reversed between readings. This is necessary in order to eliminate the effects of thermal electromotive forces.

The temperature shall be determined by means of calibrated platinum-platinum 10 per cent rhodium thermocouples, in conjunction with a potentiometer or pyrometer of such construction as to insure an accuracy corresponding to a temperature uncertainty not exceeding 10° C.

RESULTS

Temperature-Resistance Curve.

8. A curve shall be plotted showing the change of resistance with temperature. The time interval between successive readings shall be noted on the curve sheet. The curve as thus obtained with descending temperature, shall be considered as defining the true temperature-resistance characteristics of the material tested.

Singular Points.

9. If there are indications that the curve is not smooth at any point, the specimen shall again be carried through the temperature cycle, and temperature and resistance readings taken at intervals of approximately 25° C. in the suspected region.

TENTATIVE METHODS OF CHEMICAL ANALYSIS OF METALLIC MATERIALS FOR ELECTRICAL HEATING[1]

Serial Designation: B 71 - 27 T

This is a **Tentative Standard,** published for the purpose of eliciting criticism and suggestions, and as such is subject to annual revision.

ISSUED, 1927.

DETERMINATION OF NICKEL

SOLUTIONS REQUIRED

Concentrated Sulfuric Acid (sp. gr. 1.84).

Concentrated Nitric Acid (sp. gr. 1.42).

Concentrated Hydrochloric Acid (sp. gr. 1.19).

Dilute Sulfuric Acid (1:1).—Slowly stir 100 cc. of H_2SO_4 (sp. gr. 1.84) into 100 cc. of water.

Dilute Sulfuric Acid (1:99).—Slowly stir 10 cc. of H_2SO_4 (sp. gr. 1.84) into 990 cc. of water.

Tartaric Acid (20-per-cent).

Ammonium Hydroxide (sp. gr. 0.90).

Dilute Acetic Acid (1:3).—Mix 1 cc. of acetic acid (sp. gr. 1.04) and 3 cc. of water.

Nitro-Hydrochloric Acid.—Mix 10 cc. of concentrated HNO_3 (sp. gr. 1.42), 30 cc. of concentrated HCl (sp. gr. 1.19) and 40 cc. of water.

Ammonium Bisulfite.—Dissolve 1 g. of ammonium bisulfite in 5 cc. of hot water.

Sodium Dimethylglyoxime.—Dissolve 3 g. of dimethylglyoxime in 100 cc. of NaOH (3-per-cent), made fresh each time used.

METHOD

Dissolve exactly 1 g. of the alloy sample in 20 cc. of nitro-hydrochloric acid in a covered 600-cc. beaker. Add 20 cc. of dilute H_2SO_4

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[1] Criticisms of these Tentative Methods are solicited and should be directed to Mr. F. E. Bash, Secretary of Committee B-4 on Metallic Materials for Electrical Heating, Technical Department, Electrical Alloy Division, Driver-Harris Co., Morristown, N. J.

(1 : 1) and evaporate the liquid carefully to fumes of sulfur trioxide. When the beaker and its contents have cooled, add 100 cc. of water and allow the solution to digest at a low heat until all salts have dissolved. Filter the solution on a 9-cm. paper to remove any silica, and wash the paper and residue thoroughly with hot water or, if an insoluble residue is present, wash with dilute H_2SO_4 (1:99). Ignite the precipitate at a low heat, and treat with 2 cc. of HF, and several drops of concentrated H_2SO_4 in a platinum crucible, and evaporate to dryness. Fuse the residue with a little sodium carbonate, dissolve in HCl and add to the main nickel solution.

Transfer the nickel solution to a 250-cc. graduated flask, and dilute to the mark with cold water. Mix and draw off exactly 50 cc. by means of an accurately calibrated pipette, and transfer this aliquot portion to a 600-cc. beaker. This aliquot portion represents 0.2 g. of the original sample. Add 25 cc. of a 20-per-cent solution of tartaric acid (enough to hold all the iron and chromium in solution), make the solution alkaline with NH_4OH, and then make it acid with an excess of 15 cc. of concentrated HCl (sp. gr. 1.19). Add 35 cc. of a *freshly prepared* solution of sodium dimethylglyoxime, and make the solution ammoniacal, and then make it just acid with dilute acetic acid (1:3). Stir the solution vigorously and allow it to stand at a temperature of from 75 to 90° C., with occasional stirring, for one hour. If an alcoholic solution of dimethylglyoxime was used to precipitate the nickel, the contents of the beaker should be digested at a temperature just short of the boiling point until the odor of alcohol can no longer be detected.

Filter the scarlet precipitate of nickel dimethylglyoxime on a tared Gooch crucible. Wash thoroughly with hot water and dry at 110° C. to constant weight. Cool in a desiccator and weigh. The weight of nickel dimethylglyoxime multiplied by 20.32 and again by 5 gives the percentage of nickel in the sample. This method yields results that are correct within ± 0.35 per cent.

If greater accuracy is desired, use a larger aliquot portion with proportionally larger amounts of reagents and filter the nickel dimethylglyoxime precipitate on an 11-cm. paper and wash thoroughly 18 or 20 times with hot water. Return the paper and precipitate to the 600-cc. beaker, treat with 5 cc. of concentrated H_2SO_4 (sp. gr. 1.84) and 25 cc. of concentrated HNO_3 (sp. gr. 1.42) and boil the liquid gently until strong fumes of sulfur trioxide are evolved.

Having allowed the beaker and its contents to cool somewhat, add 10 cc. of concentrated HNO_3 (sp. gr. 1.42) and repeat the evaporation. Rinse the cover and sides of the beaker with a fine jet of water and fume the solution again to insure the expulsion of every trace of the HNO_3. When cool, add approximately 50 cc. of cold water and boil the contents of the beaker for several minutes, which should result in a perfectly clear solution.

Neutralize with NH_4OH and add an excess of 20 cc. NH_4OH (sp. gr. 0.90). Add 1 g. of ammonium bisulfite dissolved in 5 cc. of hot water. Now electrolize the nickel sulfate solution with a current of from 1 to 2 amperes, using a platinum-gauze weighed cathode and a spiral platinum anode. Continue the electrolysis until the solution has become colorless, and then continue for at least 15 minutes longer. Now test the solution by adding 1 or 2 drops of it to a solution of potassium sulfocyanate. Wine color indicates the presence of nickel. The amount of the solution withdrawn for this test will not affect the results and may be neglected. This test will show whether or not the electrolysis has been completed. Wash the metal deposited on the cathode with water. Remove the cathode and dip it first into a beaker of distilled water and then into absolute alcohol, dry for a few minutes at a temperature of 80 to 100° C., and weigh. The increase in weight of the cathode multiplied by 100 and divided by the weight of the sample taken gives the percentage of nickel in the sample.

DETERMINATION OF CHROMIUM BY THE PERSULFATE METHOD

SOLUTIONS REQUIRED

Silver Nitrate Solution (0.5-per-cent).—Dissolve 5 g. of $AgNO_3$ in 1000 cc. of water.

Ammonium Persulfate (15-per-cent).—Dissolve 15 g. of the salt in 100 cc. of water. (The solution should be kept in a cool place and should not be used if over three days old. A fresh solution is preferable).

Sodium Chloride (10-per-cent).—Dissolve 100 g. of NaCl in 1000 cc. of water.

Nitro-Hydrochloric Acid.—Mix 30 cc. of concentrated HCl (sp. gr. 1.19), 10 cc. of concentrated HNO_3 (sp. gr. 1.42), and 40 cc. of water.

Sulfuric Acid (1:1).—Slowly stir 500 cc. of concentrated H_2SO_4 (sp. gr. 1.84) into 500 cc. of water.

Standardized Ferrous Ammonium Sulfate Solution.—Dissolve 39.25 g. of ferrous ammonium sulfate in distilled water, add 20 cc. of dilute H_2SO_4 (1:1), dilute to 1 liter, mix thoroughly and standardize against 0.1 *N* potassium permanganate, which has in turn been standardized against the U. S. Bureau of Standards Sodium Oxalate. This solution should be standardized just before using, as its value may change from day to day. One cubic centimeter of 0.1 *N*. solution equals 0.001733 g. of chromium.

Standard Potassium Permanganate Solution (0.1 N).—Dissolve approximately 3.18 g. of pure potassium permanganate in 300 cc. of hot distilled water, boil for 10 to 15 minutes, cool to room temperature, and filter on asbestos. Transfer the solution to a glass-stoppered bottle and allow it to stand for two weeks, at the end of which time filter again on asbestos and transfer to a liter flask and dilute to the mark. This solution should be kept in a dark bottle. After a preliminary standardization against the U. S. Bureau of Standards Sodium Oxalate dilute so as to be exactly 0.1 *N*, and verify this strength by a second comparison with sodium oxalate.

METHOD

Treat approximately 0.2000 g. of the sample in a 500-cc. flask with 20 cc. of nitro-hydrochloric acid and 0.5 cc. of HF (48-per-cent), warm at a moderate temperature (about 60° C.) until the reaction is complete. Add 20 cc. of dilute H_2SO_4 (1:1), 50 cc. of water, and evaporate just to fumes of sulfuric acid. If any salts separate out, redissolve by adding 250 cc. of water and digest on a hot plate until an entirely clear solution results. Remove from the plate and add 1 cc. of $AgNO_3$ solution (0.5-per-cent), and sufficient ammonium persulfate (approximately 15 cc. for 10 to 12-per-cent chromium alloys and 25 cc. for 20-per-cent chromium alloy) to thoroughly oxidize the manganese, and boil for 3 minutes. Add 20 cc. of NaCl solution (10-per-cent), heat on a plate until the manganese dioxide has dissolved completely and boil for five minutes. Cool to room temperature, and add from a burette standardized ferrous ammonium sulfate until the solution turns green, and then add 5 cc. in excess. Titrate this excess back with 0.1 *N* potassium permanganate.

Calculate the percentage of chromium from the following formula

$$\text{Percentage of Chromium} = \frac{[(A \times B) - C] \times 0.001733}{0.2, \text{ or weight of sample}} \times 100$$

where A = volume in cubic centimeters of ferrous ammonium sulfate used;

B = normality factor of ferrous ammonium sulfate, determined daily;

C = volume in cubic centimeters of 0.1 *N* potassium permanganate used.

DETERMINATION OF IRON
BY THE
CUPFERRON METHOD

SOLUTIONS REQUIRED

Dilute Hydrochloric Acid (1: 1).—Mix equal parts of concentrated HCl (sp. gr. 1.19) and water.

Dilute Hydrochloric Acid (1:19).—Mix 5 cc. of concentrated HCl (sp. gr. 1.19) and 95 cc. of water.

Dilute Ammonium Hydroxide (1:19).—Mix 1 cc. of NH_4OH (sp. gr. 0.90) and 19 cc. of water.

Dilute Sulfuric Acid (1:4).—Slowly stir 1 cc. of concentrated H_2SO_4 (sp. gr. 1.84) into 4 cc. of water.

Dilute Sulfuric Acid (1:9).—Slowly stir 1 cc. of concentrated H_2SO_4 (sp. gr. 1.84) into 9 cc. of water.

Stannous Chloride Solution.—Dissolve 50 g. of stannous chloride in 100 cc. of concentrated HCl (sp. gr. 1.19) and dilute to 1000 cc.

Cupferron (6-per-cent).—Freshly prepared filtered cupferron ($C_6H_5(NO)ONH_4$).

METHOD

For alloys containing 10 per cent or more of iron, use a 1-g. sample, and for alloys containing 2 per cent or less of iron use a 5-g. sample. Dissolve the sample in a 400-cc. covered beaker in 25 to 75 cc. of concentrated HCl (sp. gr. 1.19) at a temperature of about 65° C. Add 2 cc. of concentrated HNO_3 (sp. gr. 1.42), and from 20 to 25 cc. of concentrated H_2SO_4 (sp. gr. 1.84), and evaporate the solution until fumes of sulfur trioxide are given off. After having allowed the beaker and its contents to partly cool, add 50 cc. of warm water and boil the solution for several minutes to dissolve all salts. Filter the liquid on an 11-cm. paper containing some paper pulp, and wash the residue and filter thoroughly with warm water. Reserve the filtrate. Ignite any residue in a platinum crucible until the carbon of the filter paper has burned off. After allowing the crucible to cool, add one or two drops of concentrated H_2SO_4 (sp. gr. 1.84) and several cubic centimeters of HF and evaporate the solution to dryness. Any remaining residue is fused with a few grams of sodium carbonate. Dissolve the fusion in dilute HCl (1:1) and boil to expel carbon dioxide. Add a slight excess of dilute NH_4OH (1:19) and boil the solution for several minutes. Filter, and wash well with hot water. Dissolve the precipitate off of the filter in 20 cc. of hot dilute H_2SO_4 (1:4) and add it to the main filtrate which should have a total volume of not more than 150 cc. Cool the solution to about 15° C., treat with a slight excess of cold, freshly prepared solution of cupferron (6-per-cent), which should cause the complete precipitation of the iron while all the nickel and chromium should remain in solution. A brownish-red, partly amorphous, partly crystallin precipitate should separate out.

As soon as a drop of the reagent causes the formation of a transient snow-white crystallin precipitate, all of the iron is down. Add some ashless paper pulp, and filter the contents of the beaker on an 11-cm. paper, wash the precipitate 18 to 20 times with cold dilute H_2SO_4 (1:9) and finally wash 5 or 6 times with cold dilute NH_4OH (1:19). Discard the filtrate. This ammonia wash dissolves out the excess of cupferron, and will also dissolve any vanadium that might be present.

Ignite the cupferron precipitate, first at a low-red heat and finally at 900 to 1000° C. Transfer the iron oxide to a 150-cc. covered beaker and wash the crucible with 20 cc. of hot HCl (1:1). Add 10 cc. of concentrated HCl (sp. gr. 1.19) and digest the solution at a temperature somewhat short of boiling. Add stannous chloride solution from time to time in amounts sufficient to discharge the yellow color of the ferric chloride, and to provide a few drops in excess. Finish the determination by the Reinhardt-Zimmerman method.

DETERMINATION OF MANGANESE

SOLUTIONS REQUIRED

Nitro-Hydrochloric Acid.—Mix 10 cc. of concentrated HNO_3 (sp. gr. 1.42), 30 cc. concentrated HCl (sp. gr. 1.19) and 40 cc. of water.

Concentrated Nitric Acid (sp. gr. 1.42).

Dilute Nitric Acid (1:200).—Mix 1 cc. of concentrated HNO_3 (sp. gr. 1.42) and 200 cc. of water.

Dilute Sulfuric Acid (1:3).—Slowly stir 1 cc. of concentrated H_2SO_4 (sp. gr. 1.84) into 3 cc. of water.

Standardized Ferrous Ammonium Sulfate Solution.—See the Determination of Chromium by the Persulfate Method.

NOTE.—One cubic centimeter of exactly 0.1 *N* solution equals 0.002769 g. of manganese.

Standard Potassium Permanganate Solution (0.1 N).—See the Determination of Chromium by the Persulfate Method.

METHOD

Dissolve exactly 2.000 g. of drillings in a 400-cc. beaker with 40 cc. of nitro-hydrochloric acid, and when in solution evaporate to a syrupy consistency and take up with 50 cc. of concentrated HNO_3 (sp. gr. 1.42). Evaporate this again and add 100 cc. of concentrated HNO_3 and boil down to 80 cc. Add slowly, 5.5 g. at a time, about 3 g. of potassium chlorate. Boil for at least 5 minutes after the last addition of potassium chlorate to insure complete oxidation of the chromium. Add 100 cc. of water and filter through a thin asbestos pad with suction, washing the beaker and pad thoroughly with dilute HNO_3 (1:200), leaving no trace of oxidized chromium. Transfer the pad and the precipitate into the original beaker, being sure to wash out all precipitate adhering to the sides of the funnel with cold water.

Now add 100 cc. of distilled water, 50 cc. of dilute H_2SO_4 (1:3), and 5 cc. in excess of enough ferrous ammonium sulfate to dissolve all of the manganese dioxide. (About 20 cc. should be required for the weight of alloy taken). The normality factor of the ferrous ammonium sulfate must be determined just before using. Stir until all the manganese dioxide is dissolved, and titrate the excess of ferrous ammonium sulfate with 0.1 N potassium permanganate. Occluded oxidized chromium is usually the cause for high manganese results.

Calculate the percentage of manganese from the following formula:

$$\text{Percentage of Manganese} = \frac{[(A \times B) - C] \times 0.002769}{2, \text{ or weight of sample}} \times 100$$

where A = volume in cubic centimeters of ferrous ammonium sulfate used;

B = normality factor of ferrous ammonium sulfate, determined daily;

C = volume in cubic centimeters of exactly 0.1 N potassium permanganate used.

DETERMINATION OF CARBON
BY THE
VOLUMETRIC METHOD

This method for the determination of carbon is the method for determining carbon by absorption of the carbon dioxide in barium hydroxide solution. Reference should be made to the Determination of Carbon by the Direct-Combustion Method as described in the Standard Methods of Chemical Analysis of Plain

Carbon Steel (Serial Designation: A 33) of the American Society for Testing Materials.[1]

In a laboratory where accurate results are being obtained by the gravimetric method, or where a large number of samples are to be analyzed, and good weighing methods are in use, the gravimetric method may be used as described in method (*a*) of the Determination of Carbon by the Direct-Combustion Method described in Methods A 33.[2] Where only occasional samples are to be run, it is probable that the volumetric method will give more satisfactory results.

SAMPLE

The sample should weigh at least 4 g. and should be rather finely divided in order that such a large sample may be placed in the combustion boat. Ordinary turnings are satisfactory, except that they are bulky. Usual precautions should be used in obtaining a perfectly clean sample.

APPARATUS

Boats and Lining Material.—Zirkite boats 100 mm. long, 13 mm. wide, and 8 mm. deep (inside dimensions) are most satisfactory, although alundum or porcelain boats may be used. The boats should be ignited in a muffle furnace before using. The bottom of the boat should be lined with a trench of 40-mesh high-grade chrome ore, ignited at 1000° C. and preserved in a glass-stoppered bottle. The sample should be covered with a very thin layer of alundum. Some alundum powder should be sprinkled inside the combustion tube to prevent the boat from sticking.

Flux.—Exactly 2 g. of fine drillings of ingot iron of known carbon content should be sprinkled over the sample before the alundum is placed over the top of the whole charge. The purpose of the ingot iron is not to flux the sample, but is a source of additional heat due to its rapid combustion when the oxygen is turned on. The results must be corrected for the amount of carbon added through the use of ingot iron.

Furnace and Combustion Tube.—The standard electric combustion furnace in common use may be used, but as the temperatures are considerably higher, the life of the heating element will be shorter than usual. A pyrometer should always be used. A fused-silica tube 24 in. in length and 1 in. in diameter gives the best results. The ends of the tubes should be encased in water-cooled jackets, or strips of blotting paper partly immersed in water should be placed over the ends of the tubes. At least 8 in. of the tube next to the

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[1] 1927 Book of A.S.T.M. Standards, Part I, p. 276.

[2] *Ibid*, p. 278.

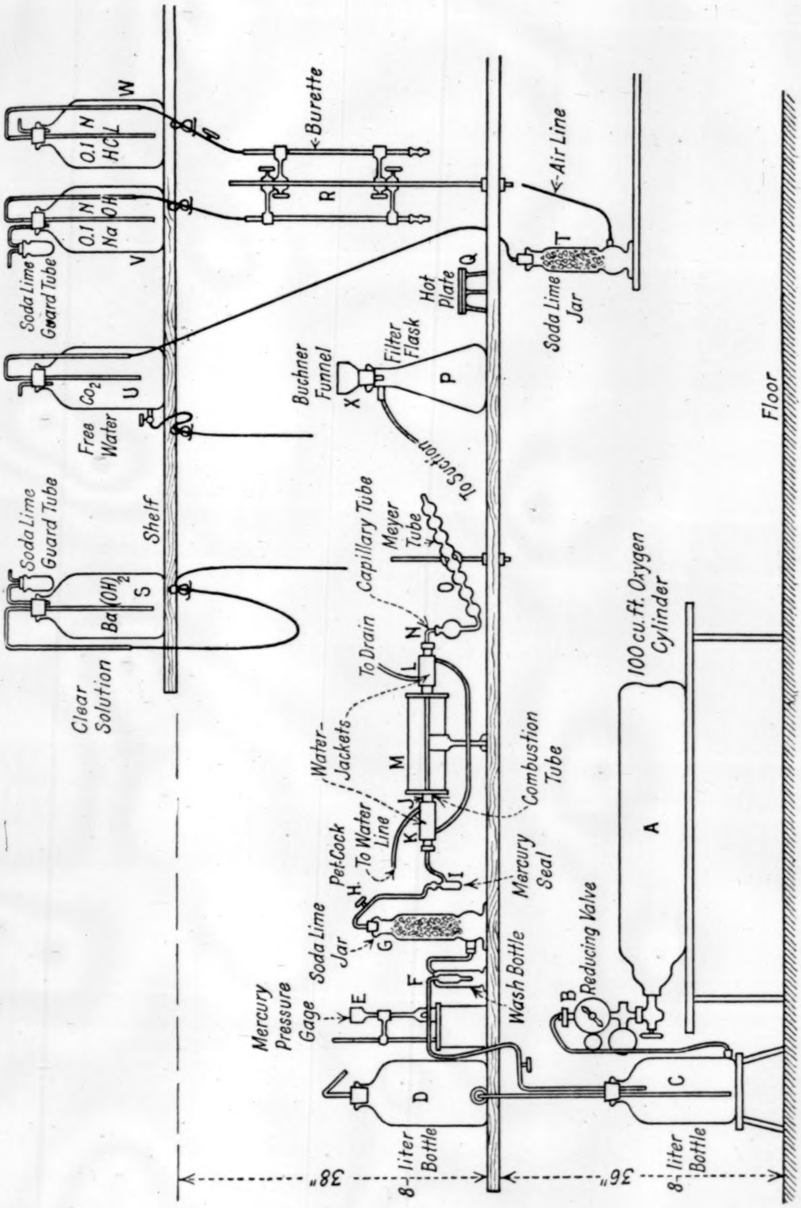
Clear Solution
Soda Lime Guard Tube
$Ba(OH)_2$
S
Shelf
Free Water
CO_2
U
Soda Lime Guard Tube
0.1 N NaOH
V
0.1 N HCL
W
Burette
R
Buchner Funnel
X
Filter Flask
P
Hot Plate
Q
Soda Lime Jar
T
Air Line
To Suction
Capillary Tube
Meyer Tube
O
N
To Drain
L
Water-Jackets
M
Combustion Tube
J
K
To Water Line
Pet-Cock
H
Mercury Seal
I
Soda Lime Jar
G
Wash Bottle
F
Mercury Pressure Gage
E
Reducing Valve
B
100 cu. ft. Oxygen Cylinder
A
D
8-liter Bottle
C
8-liter Bottle
38"
36"
Floor

FIG. 1.—Apparatus for the Determination of Carbon by the Volumetric Method.

absorption apparatus is filled with asbestos fiber which has been saturated with a solution of ferric nitrate and heated overnight at 1000° C. Ferric oxide will serve to oxidize any carbon monoxide formed, and will convert any sulfur dioxide to ferric sulfate. In case a combustion tube 30 in. in length is used, the dead space in the end next to the absorption apparatus should be filled with a glass plunger, which will decrease the amount of gas that has to be flushed out at each determination. The glass plunger may consist of a glass cylinder with the ends closed.

Detailed Description of Apparatus.—Figure 1 illustrates the details of the apparatus. Oxygen from the 100 cu. ft. cylinder *A*, passes through the reducing valve *B*, to the lower 8-liter-capacity bottle *C*, from which it forces distilled water to the upper bottle *D*, which is 2.5 ft. higher than *C*. When the lower bottle is nearly full of oxygen, the valve *B* is closed and the gas, now under reduced pressure, can be supplied to the apparatus at the desired rate by means of the pet-cock *H*. One of the essential parts of the apparatus is the mercury pressure gage *E*, which has a 6-in. scale with $\frac{1}{8}$-in. subdivisions, for indicating the *pressure*, and, when calibrated, the *rate of flow* of the oxygen.

To calibrate the gage, the Meyer tube *O*, is filled to the usual point and the oxygen is regulated until the mercury stands at the desired mark, say $1\frac{1}{8}$ in. The volume of oxygen passing through the apparatus per minute is then determined by collecting it over water in a graduated cylinder, the connection being made to the exit end of the Meyer tube by means of a rubber tube. The rate of flow at 1-in. pressure should be about 100 cc. per minute, although, of course, this varies with the resistance offered to the flow of the oxygen by the reagents and materials in the train.

The capillary tube *N*, in the stopper at the exit of the combustion tube *J*, is an essential part of the apparatus. The size of the capillary opening is adjusted by heating in a flame so that when the mercury gage indicates a certain definite pressure (about 1 in.), the rate of flow through the capillary, the Meyer tube, *O*, being filled and connected, closely approximates but does not exceed 100 cc. per minute. If the rate of flow much exceeds 100 cc. per minute some carbon dioxide will be swept through the barium hydroxide without being absorbed, while if it is much less than 100 cc. all of the carbon dioxide will not be flushed out of the combustion tube in the specified time. Removal of any carbon dioxide in the oxygen is effected by passage through NaOH solution (sp. gr. 1.27) contained in the wash bottle *F*, and the 12-mesh soda lime in the jar *G*, although the principal function of the liquid in *F* is to serve as an indicator of the rate of flow of the gas. The mercury seal *I*, prevents any possibility of back flow of the gases in the combustion tube. After passing through the mercury seal the oxygen enters the combustion tube *J*, which is provided with tightly-fitting one-hole rubber stoppers and with water jackets, *K* and *L*, at the ends. The clear solution of barium hydroxide (20 g. per liter) in the bottle *S*, is arranged so that it can be conveniently siphoned into the eight-bulb Meyer tube, *O*. The barium carbonate is filtered on the Buchner funnel *X*, shown fitted to the filter flask *P*, and the precipitate is washed with carbon-dioxide-free distilled water (prepared by bubbling through the water, compressed air previously freed from carbon dioxide by passage through the soda-lime bottle *T*, delivered by gravity from the bottle *U*). The standard 0.1 *N* solutions of NaOH and HCl are delivered by gravity to the burettes, *R*, from the bottles *V* and *W*. The small hot plate *Q*, is used for warming the flask containing the barium carbonate and the measured amount of 0.1 *N* HCl, in order to cause rapid and complete solution of the precipitate.

METHOD

The furnace having been previously heated to approximately 1100° C., all air having been displaced from the apparatus by passage of a stream of pure oxygen, and the Meyer tube having been filled with sufficient barium hydroxide solution (20 g. per liter) to fill seven of the eight bulbs when the oxygen is passing at the maximum rate, the boat is quickly inserted, by means of a stout copper rod, into the hottest part of the furnace and the stopper immediately replaced. Allow the boat and its contents to heat for about 1 minute with no oxygen passing, this will result in some oxygen being absorbed by the iron, and the barium hydroxide being drawn back into the large bulb as a consequence of the partial vacuum resulting therefrom. At the expiration of about one minute, admit oxygen to the tube at a rate of approximately 340 cc. per minute (as indicated by the gage, which should read about $1\frac{1}{2}$ in.). Complete combustion of the ingot iron, and the alloy sample, with vivid incandescence, should result in $1\frac{1}{2}$ to 2 minutes. Preliminary heating followed by the rapid admission of oxygen are absolutely essential to securing complete combustion in the short time allowed. Only in case the oxides are so thoroughly fused as to show no trace of the shape of the original drillings when the boat is removed from the furnace, should the combustion be considered to have been successful. Upon the appearance of the faintest cloudiness in the first bulb of the Meyer tube, decrease the rate of flow immediately to 100 cc. per minute (about 1 in. on the gage), and maintain it so to the end of the operation. If the rate of flow after the first noticeable formation of barium carbonate is much less or much greater than 100 cc. per minute, low carbon results will be obtained, due either to some carbon dioxide not having been swept out of the apparatus in the time specified, or to some having escaped absorption in the barium hydroxide. Passage of oxygen for a total of 5 minutes is sufficient to sweep all carbon dioxide from the combustion tube.

At the conclusion of the above described operations (6 minutes after the boat was inserted into the furnace) remove the boat, and filter the contents of the Meyer tube on two super-imposed, open-grain, 11-cm. filter papers supported on a Buchner funnel fitted to a suction flask. Wash the Meyer tube three times with water free from carbon dioxide (prepared by passing compressed air through soda-lime and then bubbling it through the distilled water), taking care to reach all points of the tube; then give the precipitate and paper four additional washings. Delivery of the water from an overhead bottle rather than from a wash flask avoids danger of contamination from the carbon dioxide of the breath, besides being more convenient and sanitary. Transfer the paper and precipitate to a 500-cc. Erlenmeyer flask and add from a burette enough standard 0.1 *N* HCl solution to dissolve the barium carbonate and add 5 cc. in excess, a portion of the acid being used to rinse the Meyer tube, which is then further rinsed with water. Place the flask containing the precipitate on a hot plate until the carbonate has dissolved; long heating should be avoided as it apparently causes some action on the filter paper involving a slight error in the determination. Introduce 5 or 6 drops of methyl orange into the solution and determine the excess of HCl by titration with a standard 0.1 *N* solution of NaOH, the end point being marked by the color change from red to yellow. One cubic centimeter of standard 0.1 *N* HCl equals 0.000600 g. of carbon.

A blank should be run on the ingot iron, boat, filter paper, etc., and any carbon found should be deducted from that obtained in the analysis. A 2-g. sample of ingot iron should be used, and the determination made by the method as just described.

DETERMINATION OF INSOLUBLE RESIDUE

METHOD

The sample should weigh at least 5 g. and if the alloy is known to be low in insoluble residue a 10-g. sample should be used. Treat the sample with from 200 to 400 cc. of HCl (sp. gr. 1.19) at a temperature of from 60 to 70° C. until the reaction appears to be complete, then add 1 to 2 cc. of HNO_3 (sp. gr. 1.42). Boil the solution for about 2 minutes, dilute with an equal volume of hot water, filter, and wash the filter thoroughly with hot dilute HCl (5:95).

Ignite the residue at a low heat in a platinum crucible, treat with HF and several drops of dilute H_2SO_4 (1:1), and evaporate the solution just to fumes of sulfur trioxide. If any residue remains, add 10 cc. of water to the crucible, filter on a 9-cm. paper and wash the residue with hot water. Ignite any residue remaining on the paper and weigh. The increase in weight multiplied by 100 and divided by the weight of sample taken gives the percentage of insoluble residue.

DETERMINATION OF SILICON

METHOD

Treat a 2-g. factor-weight sample (0.9344 g.) to a 5-g. factor-weight sample (2.3360 g.) in a 300-cc. porcelain casserole with 30 to 50 cc. of HCl (sp. gr. 1.19), the casserole being covered with a watch glass, and warm until the reaction is complete. Add 30 to 50 cc. of dilute H_2SO_4 (1:1), and evaporate just to fumes of sulfur trioxide. Allow the casserole to partly cool, add 200 cc. of warm water and boil briskly for several minutes to dissolve all salts. Filter the silica on an 11-cm. paper containing some ashless paper pulp, wash five or six times with dilute HCl (1:100), and finally with hot water until free from acid.

Ignite the paper and the precipitate in a small platinum crucible, first at a dull-red heat until the carbon of the filter paper has been oxidized, and finally at 1050 to 1100° C. Allow the crucible to cool in a desiccator and weigh. Add 1 or 2 drops of H_2SO_4 (sp. gr. 1.84), several cubic centimeters of HF, and evaporate the solution until all the H_2SO_4 has been expelled. Ignite the crucible again, cool, and weigh. The difference between the first and the second weights, multiplied by 100 and divided by the weight of sample taken, gives the percentage of silicon in the sample. In case the silica precipitate contains any undissolved material, ignite the paper and the precipitate at a dull-red heat until the carbon of the filter paper has been oxidized, transfer to a 30-cc. pure-iron crucible, and fuse with approximately 5 g. of sodium peroxide. When cool, transfer the melt to a 300-cc. porcelain casserole and dissolve in 50 cc. of water. Add 50 cc. of dilute H_2SO_4 (1:1), and evaporate the solution just to fumes of sulfur trioxide. From this point proceed as described above.

TENTATIVE SPECIFICATIONS
FOR
SAND FOR USE IN LIME PLASTER[1]

Serial Designation: C 66 – 27 T

This is a **Tentative Standard,** published for the purpose of eliciting criticism and suggestions, and as such is subject to annual revision.

ISSUED, 1927.

Definition. 1. Sand may be defined as follows:[2]

Sand.—The fine granular material (usually less than $\frac{1}{4}$ in. in diameter) resulting from the natural disintegration of rock, or from the crushing of friable sand-stone rocks.

NOTE.—When used without a qualifying adjective, "sand" is generally understood to mean the product of the natural disintegration of siliceous or calcareous rock. Sand should be distinguished from screenings, gravel, etc. The size of particle and other physical characteristics should be taken care of in specifications. The fine material resulting from the crushing of blast-furnace slag is known as "slag sand."

General Requirements. 2. Sand for lime plaster shall consist of hard, strong, durable, uncoated, mineral or rock particles (as limited by the above definition), free from injurious amounts of saline, alkaline, organic, or other deleterious substances.

Grading. 3. Sand for lime plaster shall be uniformly graded from fine to coarse within the following limits:

Retained on a No. 8 (2380-micron) sieve	not more than 10 per cent
Retained on a No. 30 (590-micron) sieve	not more than 80 per cent not less than 15 per cent
Retained on a No. 50 (297-micron) sieve	not more than 95 per cent not less than 20 per cent
Retained on a No. 100 (149-micron) sieve	not less than 95 per cent
Weight removed by decantation	not more than 5 per cent

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[1] Criticisms of these Tentative Specifications are solicited and should be directed to Mr. H. C. Berry, Chairman of Committee C-7 on Lime, University of Pennsylvania, Philadelphia, Pa.

[2] As defined by Committee E-8 on Nomenclature and Definitions in the Tentative Definitions of the Terms Sand and Aggregate (Serial Designation: C 58 – 26 T) of the American Society for Testing Materials, see *Proceedings*, Am. Soc. Testing Mats., Vol. 26, Part I, p. 787 (1926); also 1927 Book of A.S.T.M. Tentative Standards, p. 232.

Sieve Analyses. 4. The sieve analysis shall be made in accordance with the Standard Method of Test for Sieve Analysis of Aggregates for Concrete (Serial Designation: C 41) of the American Society for Testing Materials.[1]

Decantation Test. 5. The decantation test shall be made in accordance with the Tentative Method of Decantation Test for Sand and Other Fine Aggregates (Serial Designation: D 136 – 22 T) of the American Society for Testing Materials.[2]

Organic Impurities. 6. Sand, when tested in accordance with the Standard Method of Test for Organic Impurities in Sands for Concrete (Serial Designation: C 40) of the American Society for Testing Materials,[1] shall show a color not darker than the standard color, unless it is shown by adequate tests that the impurities causing the color are not harmful in plaster.

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[1] 1927 Book of A.S.T.M. Standards, Part II.

[2] *Proceedings*, Am. Soc. Testing Mats., Vol. 22, Part I, p. 802 (1922); also 1927 Book of A.S.T.M. Tentative Standards, p. 501.

TENTATIVE METHODS OF CHEMICAL ANALYSIS OF LIMESTONE, QUICKLIME AND HYDRATED LIME[1]

Serial Designation: C 25 - 27 T

This is a **Tentative Standard,** published for the purpose of eliciting criticism and suggestions, and as such is subject to annual revision.

ISSUED, 1919; REVISED, 1921, 1922, 1925, 1926, 1927.

TREATMENT OF SAMPLE

Treatment of Sample.

The sample, taken and prepared in accordance with the requirements of the particular specifications of the Society applicable to the material shall be treated as follows:

Weigh out approximately 0.5 g. of the substance (Note 1) and, if a limestone or hydrated lime, ignite in a covered platinum crucible in an electric muffle (Note 2) for 15 minutes, or longer if the heat is not powerful enough to effect complete decomposition within that time. Transfer to an evaporating dish, preferably of platinum (Note 3) for the sake of celerity in evaporation, mix to a thin slurry with distilled water, add 5 to 10 cc. of HCl (sp. gr. 1.20) and digest with aid of gentle heat and agitation until solution is complete. Solution may be aided and the time shortened by light pressure with the flattened end of a glass rod upon resistant lumps. Then evaporate the solution to dryness, so far as this may be possible on the water bath.

DETERMINATION OF SILICA AND INSOLUBLE MATTER, INCLUDING SILICA.

Silica and Insoluble Matter.

When dry or nearly so, place the dish and its contents in an air bath or (covered) on a platinum triangle resting on a hot plate and, if it is a high calcium limestone that is under treatment, heat for one hour at 200° C.; if a high magnesian stone is under treatment the temperature should not exceed 120° C. Drench the cooled mass with HCl (sp. gr. 1.20) and allow to stand for a few minutes. Add an equal volume of water, cover the dish and place on the water bath for

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[1] Criticisms of these Tentative Methods are solicited and should be directed to Mr. H. C. Berry, Chairman of Committee C-7 on Lime, University of Pennsylvania, Philadelphia, Pa.

Bulletin 700, U. S. Geological Survey, should be used as a reference book in connection with these methods, especially when very exact and detailed analyses are desired. Blank determinations should be made on all reagents, and corrections applied when called for.

10 minutes (Note 4). Separate the silica by filtration on a filter of suitable size. Wash thoroughly with dilute HCl and then wash twice with cold water.

Evaporate the filtrate to dryness. Extract the residue with HCl as before but allowing only a few minutes time. Filter this solution through a second and smaller paper.

Transfer, wet, the papers containing the separated residue to a weighed platinum crucible. Char carefully without allowing the paper to inflame, and ignite to constant weight in an electric muffle, and weigh (Note 2). The increase in weight represents the insoluble and siliceous matter and is reported as insoluble matter, including silica.

Silica:

To determine the amount of silica (SiO_2), treat the "insoluble matter, including silica," in the crucible with 5 cc. of water, 5 cc. of HF and one or two drops of H_2SO_4,[1] and evaporate to dryness. Heat the residue for 2 or 3 minutes in an electric muffle and again weigh. The difference between this weight and that previously obtained gives the weight of "silica" (SiO_2) (Note 5).

If the silica is determined by volatilization with HF, the residue in the crucible is fused with a little Na_2CO_3 (Note 6), and the cooled melt is dissolved in diluted HCl and the solution added to the filtrate from the second evaporation for "insoluble matter, including silica." If the "insoluble matter, including silica," is reported as such and no HF treatment is given, the "insoluble matter, including silica," is not fused or further treated.

Insoluble Matter, Excluding Silica:

The difference between the weight of "insoluble matter, including silica," and "silica" represents the "insoluble matter, exclusive of silica."

DETERMINATION OF TOTAL IRON AND ALUMINUM.

Iron and Alumina.

To the HCl solution from the determination of silica add a few drops of bromine water or HNO_3 and boil the solution until all trace of bromine or chlorine is gone. Then add HCl, if not already present, sufficient to insure a total volume of 10 to 15 cc. of HCl (sp. gr. 1.20).[2] Add a few drops of methyl red solution and after diluting to 200 to 250 cc. heat the liquid to boiling. Neutralize by means of NH_4OH (dilute towards the end) until the color of the liquid changes to a distinct yellow. Boil for one or two minutes, allow to settle, filter and wash the precipitate at once two or three times with hot NH_4Cl (2-per-cent) solution and suck dry.[1]

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[1] See *Bulletin 700*, U. S. Geological Survey, p. 103.

[2] See *Bulletin 700*, U. S. Geological Survey, p. 258.

Set the filtrate aside. Dissolve any precipitate from the paper in hot, dilute HCl, the solution passing into the beaker in which the precipitation was made and wash the paper thoroughly with hot water. Boil the solution to expel any trace of chlorine and again precipitate the hydroxides with NH_4OH as described above. Ignite the precipitate, moist (Note 2), in a weighed platinum crucible, cool and weigh as Al_2O_3 and Fe_2O_3 (Note 7).

DETERMINATION OF TOTAL IRON.

Total Iron.

Fuse the combined iron and aluminum oxides (Note 8) in a platinum crucible at a very low temperature with 3 to 4 g. of $K_2S_2O_7$ or better $Na_2S_2O_7$ (Note 9). Take up the melt with so much dilute H_2SO_4 that there shall be not less than 5 g. absolute acid and enough water to effect solution on heating. Evaporate the solution and eventually heat until acid fumes come off copiously. After cooling and redissolving in water, filter out the small amount of silica, wash, ignite, weigh and correct by HF and H_2SO_4 (Note 10). Add the weight so corrected to the weight of silica previously found and deduct from the gross weight of the oxides of iron and aluminum.

Reduce the filtrate by zinc (Note 11). Titrate with $KMnO_4$ using a N/20 solution.

DETERMINATION OF ALUMINUM.

Aluminum.

Subtract the calculated weight of Fe_2O_3 obtained by the method described above from the weight of $Fe_2O_3 + Al_2O_3$. Report the remainder as Al_2O_3. In case phosphorus is determined, calculate it to P_2O_5 and deduct also.

DETERMINATION OF TOTAL IRON.

ALTERNATIVE METHOD (Note 8).

Total Iron, Alternative.

Dissolve 2 to 5 g. (depending upon the amount of iron present) of the properly prepared sample in HCl and evaporate rapidly to dryness. Treat the residue with water and HCl, filter off the silica and wash several times with hot water. Precipitate the iron in a boiling solution with fixed alkali, allow to settle, filter and wash free of chlorides, using hot water. Dissolve in dilute H_2SO_4.

Ignite the insoluble matter from the evaporated hydrochloric acid solution in a platinum crucible. Treat with H_2SO_4 and HF and heat until fumes of H_2SO_4 appear. Bring the residue into solution with the addition of a few drops more of H_2SO_4 and combine the solution with that of the bulk of the iron. Reduce this solution by zinc and titrate the iron with $KMnO_4$ in the usual manner.

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[1] See *Bulletin 700*, U. S. Geological Survey, p. 107.

DETERMINATION OF CALCIUM.

(Note 12.)

(*a*) *Gravimetric Method.*

Calcium, Gravimetric.

Add a few drops of NH_4OH to the combined filtrate from the R_2O_3 precipitate, and bring the solution to boiling. To the boiling solution add 35 cc. of a saturated solution of $(NH_4)_2C_2O_4$, and continue the boiling until the precipitated CaC_2O_4 assumes a granular form; then allow it to stand 20 minutes, or until the precipitate has settled and the supernatent liquid is clear, filter and wash thoroughly with boiling water (Note 13). Place the wet filter and precipitate in a platinum crucible, and burn off the paper over the small flame of a Bunsen burner, or in a muffle. Ignite the residue, dissolve in hot dilute HCl, and make up the volume of the solution to 100 cc. with water. Add NH_4OH in slight excess and boil the liquid. If a small amount of $Al_2(OH)_6$ separates, filter it out, wash with NH_4Cl (2-per-cent solution), ignite, weigh and add this weight to that found in the first determination. Then reprecipitate the lime by $(NH_4)_2C_2O_4$, allow to stand until settled, filter, wash thoroughly with boiling water (Note 13) and weigh as calcium oxide after ignition to constant weight in a covered platinum crucible.

(*b*) *Volumetric Method.* (Note 14.)

Calcium, Volumetric.

Make the filtrate from the iron and alumina precipitate alkaline with NH_4OH, boil, and add 35 cc. of a boiling saturated solution of $(NH_4)_2C_2O_4$. Stir vigorously and allow to stand until the precipitate has settled, filter on an 11-cm. paper, and wash ten times with hot water (Note 15). Transfer the paper and precipitate to the beaker in which the precipitation was made, spreading the paper out against the upper portion of the beaker. Wash the precipitate from the paper with a jet of hot water, fold the paper and leave it adhering to the upper portion of the beaker. Add to the contents of the beaker 50 cc. of dilute H_2SO_4 (1:10), dilute to a volume of 250 cc. with hot water and heat to a temperature of 80 to 90° C. Titrate with the standard $KMnO_4$ solution[1] until the pink end point is obtained. Now drop the folded filter paper (which has been adhering to the side of the beaker) into the liquid; the pink color of the latter will be discharged. Finish the titration by adding $KMnO_4$, a drop at a time, until the pink end point is again obtained. A Gooch crucible may be used instead of filter paper. From the total quantity of standard $KMnO_4$ solution used, calculate the percentage of calcium oxide.

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[1] See directions for preparing this solution.

DETERMINATION OF STRONTIUM.

Strontium. Transfer the weighed oxides obtained in the gravimetric determination of calcium to a small flask of 20-cc. capacity and dissolve in HNO_3. Evaporate to dryness and heat at 150 to 160° C. Treat the thoroughly dried nitrates with as little (rarely over 2 cc.) of a mixture of equal parts of absolute alcohol and ether as may be needed to dissolve the calcium salt, solution being hastened by occasional gentle agitation. After standing over night in the corked flask collect the insoluble matter on the smallest possible filter and wash with more of the above mixture of alcohol and ether. After drying, pass a few cubic centimeters of hot water through the filter, on which may remain a few tenths of a milligram of residue, which does not usually contain any lime or other alkaline earth and whose weight is therefore to be deducted from that of the lime, unless it can be shown that it is derived from the glass of the little flask in which the nitrates of calcium and strontium were evaporated. To the solution of strontium nitrate in a small beaker add a few drops of H_2SO_4 and then its volume of alcohol, whereby the strontium is precipitated as sulfate. After twelve hours, filter on a small filter paper and wash the residue with 50-per-cent alcohol. Ignite at a low temperature, moisten with dilute H_2SO_4, evaporate, again ignite and weigh as strontium sulfate. Test the sulfate spectroscopically as to freedom from calcium and barium.

Calculate the weight of strontium oxide and deduct from the weight of calcium oxide obtained as above.

DETERMINATION OF MAGNESIUM.

Magnesium. Acidify the combined filtrates from the calcium precipitates with HCl and concentrate on the water bath to about 150 cc., and heat to boiling. To the boiling solution add 10 cc. of a saturated solution of $Na(NH_4)HPO_4$ and continue the boiling for several minutes. Then cool to room temperature, and add NH_4OH drop by drop with constant stirring until the crystallin ammonium-magnesium orthophosphate begins to form and then in moderate excess, the stirring being continued for several minutes. Allow the liquid to stand in a cool atmosphere for from 12 to 48 hours (Note 16) and filter.

Dissolve the precipitate in hot dilute HCl, make up the solution with water to about 100 cc., add 1 cc. of the saturated solution of $Na(NH_4)HPO_4$ and NH_4OH drop by drop with constant stirring until the precipitate is again formed as above described and the ammonia is present in moderate excess. Then allow it to stand in a cool atmosphere for from 12 to 48 hours (Note 16), filter on paper or a Gooch crucible, wash with dilute NH_4OH containing NH_4NO_3 (Note 17), ignite (Note 2), cool, and weigh as $Mg_2P_2O_7$ (Note 18).

DETERMINATION OF TOTAL VOLATILE MATTER.

(LOSS ON IGNITION.)

Volatile Matter.

Place 1 g. of the properly prepared sample (Note 19) in a weighed platinum crucible, cover with the lid and heat gently for 5 minutes (Note 2), gradually increasing the temperature to the maximum of the muffle, and maintain at this temperature until constant weight is obtained (usually about 15 minutes).

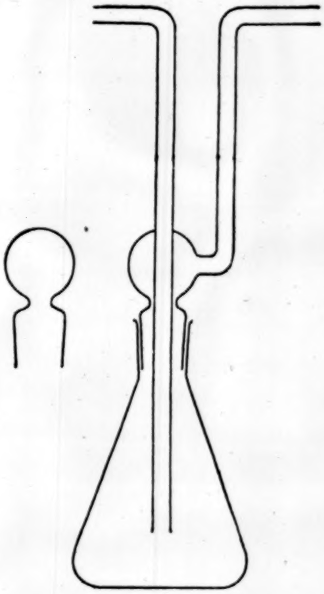

FIG. 1.—Bottle for Determination of Superficial Moisture.

DETERMINATION OF MECHANICAL MOISTURE

Mechanical Moisture.

Limestone.—Weigh 1 g. of the properly prepared sample in a tared, wide, low-form, flat-bottomed weighing bottle. Heat uncovered in a ventilated drying oven at 120° C. for two hours. Quickly stopper and cool in a desiccator. Lift the stopper momentarily just before weighing and weigh. The use of a similar weighing bottle as a counterpoise carried through all of the operations is a desirable procedure. The loss in weight represents "Mechanical Moisture" or "Hydroscopic Water" at 120° C.

Hydrated Lime.—Mechanical moisture in hydrated limes is to be determined by aspirating over the sample, in a closed container at 120° C. a slow stream of dry, CO_2-free air. The container for the sample is to be equipped with two interchangeable stoppers, one to be used during weighings and the other to be used during the drying. The second stopper is equipped with two entry tubes for conducting the air stream over the sample. (Note 20.) (See Fig. 1.)

The container is connected in a train, having before it a soda-lime tower, a lime-water bottle, a sulfuric acid bottle, and a phosphoric anhydride bulb, in the order named, and after it another protective phosphoric anhydride bulb. The lime-water bottle is useful for giving indication of the exhaustion of the soda-lime. The train is placed in position, with connection for the sample bottle, in a drying oven at 120° C.

The manipulations are as follows: Place 2.5 to 3 g. of the properly prepared sample into the previously weighed bottle, and immediately re-stopper it. A glazed paper funnel will aid rapid manipulation. Insert the bottle in the train by quickly exchanging the stoppers, and draw a slow current of dry, CO_2-free air through the apparatus for 2 hours. Remove the sample bottle from the oven with another quick exchange of stoppers, and set it in a desiccator to cool. When cool, remove it to the balance case for several minutes before weighing it, and just before weighing, lift the stopper slightly for an instant to relieve any vacuum that may exist in the bottle. The loss in weight of the sample represents "Mechanical Moisture" or "Hydroscopic Water" at 120° C.

Use a bottle similar to the one containing the sample as a counterpoise in all weighings.

DETERMINATION OF CARBON DIOXIDE.

Carbon Dioxide. Carbon dioxide is to be determined upon the properly prepared sample according to the method given in U. S. Geological Survey Bulletin No. 700, p. 217. An illustration showing the arrangement of the component parts of the necessary apparatus is shown on p. 218 of that Bulletin.

With limestone, use a 0.5 g. sample; with burned lime, hydrated lime, etc., use a 5-g. sample.

Boil the weighed sample with dilute HCl in a small Erlenmeyer flask attached to an upwardly inclined condenser, whence, after passing through a drying system—calcium chloride, anhydrous copper sulfate to retain hydrogen sulfide from decomposable sulfides and any HCl that may pass over, then calcium chloride again—the carbon dioxide is caught by absorption tubes filled with soda-lime followed by calcium chloride. Of course, arrangement is made for a current of air free from CO_2 with which to sweep out the apparatus before and after the experiment, and for a slow current during its continuance.

The results are very accurate and the determination can be quickly carried out.

The manipulations are as follows: Pour hot water upon the powder in the flask fitted with a separatory funnel and delivery tube; attach this to the condenser, and force a current of air free from CO_2 through the whole system, except the weighed absorption tubes, until the original air has been displaced, the observation bulbs (containing H_2SO_4 to show the rate of gas flow) being attached directly to the drying system. Then close the stop-cock in the separatory funnel, half fill the latter with HCl (1:1), replace the rubber stopper of the funnel, insert the absorption tubes between the drying system and the observation bulbs, and allow the acid to flow into the flask, slowly if there is much carbon dioxide, rapidly if there is but little. When effervescence diminishes in the former case, at once in the latter, light the burner under the flask and start the flow of water through the condenser. Keep the flame low, so as to secure steady but quiet ebullition, and do not interrupt the air current although it should be reduced to a slow rate. With much carbon dioxide the rate of absorption is very readily noted by holding the hand to the soda-lime tubes, which become hot or warm when absorption is taking place. Sufficient time having elapsed (Note 21), extinguish the flame, and increase the air current. When cool, disconnect the soda-lime tubes from the apparatus and allow to stand in the balance case until two weights taken 30 minutes apart agree within 0.5 mg.

The soda lime for use in this determination must be porous, not hard and unabsorptive like that sometimes used for the combustion of nitrogenous organic substances.

Alternative Method.—The apparatus illustrated in Fig. 2, which is a modification of the usual form, may be used if desired. The principle of its operation is the same as that of the procedure described above.

The apparatus consists of the following:

A tube, *A*, of decomposition of the sample.

A tube, *B*, to contain acid. A soda-lime tower is placed ahead of tube *B* so that air drawn through the apparatus is free of CO_2.

A "micro-drier," *C*, containing water, to act as a condenser and to retain most of the acid volatized from tube *A*.

A bulb, *D*, containing mossy zinc to remove the last traces of HCl.

A "micro-drier," *E*, containing H_2SO_4 to dry gases. If the sample evolves H_2S, another micro-drier, *F*, containing cadmium chloride solution is inserted between bulb *D* and micro-drier *E*.

A bulb, *G*, containing P_2O_5 to complete the drying of the gases.

A Midvale bulb, *H*, for absorption of CO_2. It is filled as follows: A layer of glass wool extending above the end of the outlet tube is placed in the bottom, and on this a layer of P_2O_5, about $\frac{3}{8}$ in. thick, Immediately on this is placed another layer of glass wool, and the rest of the bulb is filled with "Ascarite," except for a final layer of glass wool on the top.

"The manipulations are as follows: Sweep out tubes *C*, *D*, *E*, *F* and *G* with a current of CO_2-free air. Place in tube *B* sufficient HCl (sp. gr. 1.1) to completely decompose the sample, but so regulated in volume that the liquid level in tube *A* shall not be above the point *P*. Connect a soda-lime tower to the top of tube *B*.

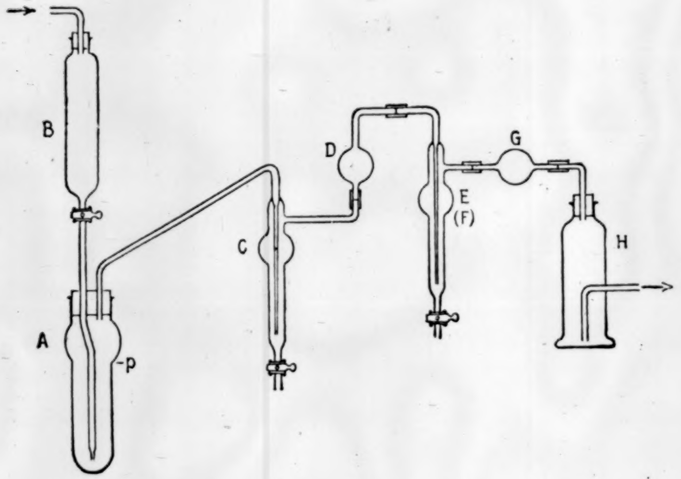

FIG. 2.—Apparatus for Determination of Carbon Residue.

With limestone, use an 0.5-g. sample; with burned lime, hydrated lime, etc., use a 3 to 5-g. sample.

Introduce rapidly into tube *A* a weighed amount (Note 1) of properly prepared sample, and immediately cover it with CO_2-free water, and attach to the apparatus. Then attach the weighed Midvale bulb. Allow the acid from tube *B* to flow into tube *A*, the rate being governed by the rate of evolution of gas. Then gently heat tube *A*, and boil to expel all CO_2 (Note 21) while drawing a slow current of CO_2-free air through the apparatus. Continue the air current for three minutes after removing the flame. Disconnect the Midvale bulb and weigh it after it has come to equilibrium in the balance case. Use a second Midvale bulb as counterpoise in all weighings.

DETERMINATION OF SULFURIC ANHYDRIDE.

Sulfuric Anhydride.

Place 2 g. of the properly prepared sample in a small, dry beaker and stir it up with 10 cc. of cold water until all lumps are broken up and the lighter particles are in suspension. Add 15 cc. of dilute HCl (1 : 1) and heat until solution is complete. Filter through a small paper and wash the residue thoroughly with hot water. Dilute the filtrate to 250 cc., heat to boiling, and add 10 cc. of a boiling 10-per-cent solution of barium chloride drop by drop with constant stirring. Stir well and allow to stand over night. Filter, wash with boiling water, ignite and weigh as $BaSO_4$.

DETERMINATION OF TOTAL SULFUR.

Total Sulfur.

Weigh 1 g. of a properly prepared sample. Add approximately 0.5 g. of sodium carbonate. Mix thoroughly in a porcelain crucible and heat gently until sintered. Then ignite for 15 minutes at a temperature of approximately 1000° C., taking care to allow access of air to the contents of the crucible. Cool and place the crucible in a 250-cc. beaker and cover with hot water. Add 10 cc. of bromine water, then 30 cc. of hydrochloric acid (1:1) and boil until solution is complete and all bromine has been expelled. Remove the crucible, washing it with water. Add a few drops of methyl red, and render the solution alkaline with ammonium hydroxide (1:1). Boil the solution for 1 or 2 minutes, filter and wash with hot water. To the filtrate add 5 cc. of hydrochloric acid (1:1), adjust the volume to about 200 cc., bring the solution to boiling and while boiling add 10 cc. of hot 10-per-cent barium chloride solution. Allow to stand over night. Filter, wash with hot water, ignite and weigh as $BaSO_4$.

NOTE.—It is usually desirable to make a fusion in a platinum crucible. However, it has been found that with limestones very high in impurities, when the fusion is made in a muffle, the damage to platinum ware is considerable. It has been proved that the use of porcelain crucibles introduces no appreciable error.

DETERMINATION OF PHOSPHORUS.

Phosphorus.

Dissolve 10 g. of the sample in 80 cc. of dilute HNO_3 (1:1), filter, and wash the residue with hot water. Ignite, and fuse the residue with a little Na_2CO_3, cool the melt and add its nitric acid solution to the main filtrate. (Note 22.)

In case the rock is rather argillaceous, mix the powder with half its weight of Na_2CO_3 and blast strongly. Dissolve the cooled melt in HNO_3 and evaporate to dryness. Take up the dry residue with dilute HNO_3 (1:2), filter and wash the residue with hot water. Ignite the residue in platinum, and evaporate with HF and HNO_3. Finally, evaporate twice with HNO_3 alone to expel all fluorine, dissolve the residue in HNO_3 and add the solution to the main filtrate. (Note 22.)

Oxidize the nitric acid solution by boiling with 10 cc. of 1.5-per-cent $KMnO_4$ solution until manganese dioxide is precipitated. Dissolve the oxide by addition of H_2SO_3 or a sulfite free from phosphorus and boil to expel the oxides of nitrogen and sulfur. Neutralize the HNO_3 with NH_4OH and then add 1 cc. of HNO_3 (sp. gr. 1.42) for every 100 cc. of solution. Bring the solution to a temperature of 40° C., add ammonium molybdate solution[1] and shake for 10 minutes. Allow to stand at a temperature of not over 40° C. for 1 to 12 hours. Filter and wash 10 times with a 1-per-cent KNO_3 solution. Return the precipitate to the precipitating vessel, add a measured excess of N/10 NaOH and 25 cc. of water free from CO_2 and shake or stir until the precipitate is dissolved. Dilute to 100 to 200 cc. with water free from CO_2, add 3 drops of 0.2-per-cent phenolphthalein solution, and discharge the pink color with standard acid. Finish the titration by adding standard alkali until the reappearance of the pink color. The alkali solution should be free from carbonate and be standardized against the Bureau of Standards' standard benzoic acid.[2] The ratio of phosphorus to NaOH should be considered as 1 : 23 in calculating results. (Note 23.)

DETERMINATION OF MANGANESE.

Manganese. Dissolve 10 g. of the sample in 100 cc. of dilute HNO_3 (1 : 1), filter and wash the residue with hot water. Ignite the residue in platinum, fuse with a little Na_2CO_3 and add the nitric acid solution of the melt to the main filtrate.

Dilute the solution to 150 cc. and add 0.5 g. of sodium bismuthate (Note 24). Heat for a few minutes, or until the pink color has disappeared and dioxide has precipitated. If manganese dioxide does not precipitate add more bismuthate. Clear the solution by adding a few drops of a saturated solution of sodium bisulfite or other suitable reducing agent free from chlorides, and boil to expel all oxides of nitrogen and sulphur. Cool to 15° C., add an excess of sodium bismuthate, agitate and let stand for a few minutes. Add 50 cc. of

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[1] See Blair, "The Chemical Analysis of Iron," 8th Edition, p. 92.

[2] See *Journal*, Am. Chem. Soc., Vol. 34, p. 1027 (1912), and Vol. 35, p. 1309 (1913).

3-per-cent HNO_3 and filter through asbestos. Wash with 3-per-cent HNO_3 until the washings run through colorless. Add a measured excess of a standard $FeSO_4$ solution and titrate back with a standard $KMnO_4$ solution of which the strength has been determined by means of the Bureau of Standards sodium oxalate. (Note 25.)

DETERMINATION OF FERROUS IRON SOLUBLE IN SULFURIC ACID.

Ferrous Iron.

In limestones, the presence of carbonaceous matter renders the exact or even approximate determination of ferrous iron often impossible. Nevertheless, even in its presence acceptable results are sometimes obtainable if there is not much of such matter and if it does not give with acid a colored solution. Occasionally limestones show films of manganese peroxide, which likewise interferes with the determination.

(*a*) *In Absence of Carbonaceous Matter.*

The powder, one to several grams, is introduced into a stout flask of about 200 to 250-cc. capacity and boiled with a little water till all air is expelled. While still boiling, dilute H_2SO_4 is added, a little at a time, till effervescence ceases, and then a further amount. Calcium sulfate precipitates, but the iron will remain in solution. The flame is then removed and a stopper tightly inserted, through which passes a small stop-cock funnel. When cool, or nearly so, cold water is poured into the funnel, the cock cautiously opened, and the water drawn into the flask, more water being poured into the funnel as fast as it empties, till the solution amounts to 100 to 150 cc. Such precaution to exclude air is hardly necessary in most cases, however, for in presence of H_2SO_4 the oxidation of ferrous iron is exceedingly slow. It is ordinarily quite sufficient to equalize the internal and external pressures by opening the cock, removing the stopper, and pouring in cold water. The flask is then brought under a burette containing dilute $KMnO_4$ solution and the iron titrated without delay. With a carbonate which is wholly decomposable without the aid of heat, solution may be accomplished in a flask filled with CO_2, using cold acid, whereby the danger of attack of silicates is lessened if these are present. If the preference is for the $K_2Cr_2O_7$ method of titration, HCl may be used instead of H_2SO_4, in absence of manganese peroxide. In this case there is, of course, no separation of an insoluble calcium salt, a fact which renders easier the subsequent determination of the iron in any insoluble residue the rock may yield. The ferrous iron thus found is mostly, if not altogether, that existing as carbonate.[1]

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[1] If a determination of ferrous iron in the insoluble residue is desired, see U. S. Geological Survey *Bulletin 700*, p. 265.

(*b*) *In Presence of Carbonaceous Matter.*

Decomposition is effected in a flask by dilute H_2SO_4 in an atmosphere of CO_2. With limestones and active agitation no heat need be used, but with dolomites it will be necessary. The solution is then quickly filtered through asbestos (in an atmosphere of CO_2 if much iron is present), the residue and filter washed a few times with water, and the filtrate titrated at once with permanganate. If it is colored by organic matter, the result may be in error. As above, HCl and titration by $K_2Cr_2O_7$ may be used in absence of manganese peroxide. In either case it is important to allow the acid to act no longer than is necessary and to filter quickly. A determination of the ferrous iron in the insoluble matter is usually not worth attempting, because of the admixed organic matter.

DETERMINATION OF AVAILABLE LIME IN QUICKLIME AND HYDRATED LIME BY THE MODIFIED SCAIFE METHOD

Available Lime. "Available lime" in quicklime or hydrated lime is that (or those) constituent (or constituents) which enters (or enter) into the reaction under the conditions of the specified method or process.

The interpretation of results obtained by the following method shall be restricted by the above definition.

Place 1.4 g. of the carefully prepared and finely ground (passing a No. 100 sieve) lime in a 400-cc. beaker, add 200 cc. of hot water, cover, heat carefully and then boil for three minutes.

Cool, wash down cover, add two drops of phenolphthalein and titrate with normal hydrochloric acid, adding the acid dropwise as rapidly as possible and stirring vigorously to avoid local excess of acid. When the pink color disappears in streaks, retard the rate of addition of acid somewhat, but continue until the pink color disappears entirely and does not reappear for 1 or 2 seconds. Note the reading and ignore the return of color.

Repeat the test, substituting for the 400-cc. beaker a 1-liter graduated flask, carrying a one-hole stopper fitted with a short glass tube drawn out to a point. Cool and add dropwise and with vigorous stirring 5 cc. less acid than before. Call the number of cubic centimeters used A. Grind up any small lumps with a glass rod flattened at one end, dilute to the mark with freshly boiled distilled water, close the flask with a solid stopper, mix thoroughly for 4 or 5 minutes and let settle for 30 minutes.

Pipette a 200-cc. portion add phenolphthalein and titrate slowly with 0.5 N hydrochloric acid until the solution remains colorless on standing 1 minute. Call this additional number of cubic centimeters B. Then the percentage of available $CaO = 2A + 5B$.

NOTES.

To secure accurate and concordant results, it is essential that this method be followed in minute detail.

For very accurate work 0.1 *N* acid may be used in place of the 0.5 *N* acid prescribed. The calculation then becomes: Available $CaO = 2A + B$.

Standard acid solutions must be standardized by the U. S. Bureau of Standards benzoic acid No. 48-A through a sodium hydroxide solution.

PREPARATION OF STANDARD SOLUTION OF POTASSIUM PERMANGANATE.

Potassium Permanganate.

Prepare a solution of potassium permanganate containing 5.64 g. of the pure crystallized salt in each liter. Such a solution will be of such strength that 1 cc. will approximately equal 0.005 g. of CaO (Note 26).

The best and simplest way to prepare such a solution is to weigh out the required quantity of potassium permanganate and place in a bottle containing the proper volume of water a week or ten days before the solution is to be standardized. The bottle and its contents must be kept in a dark place and shaken occasionally for the first three or four days. When ready for standardization, siphon off the solution through a glass siphon into another bottle, leaving a depth of about one inch of solution undisturbed in the original bottle (Note 27). Thoroughly mix the solution in the second bottle by shaking and standardize as follows (Note 28):

Dissolve 0.5 g. of $Na_2C_2O_4$ (Note 29) in a 400-cc. beaker with 200 to 250 cc. of hot water (80 to 90° C.) and add 10 cc. of dilute H_2SO_4 (1 : 1) to the solution. Titrate at once with the permanganate solution being standardized, stirring vigorously and continuously. The permanganate solution must not be added more rapidly than 10 to 15 cc. per minute, and the last 0.5 to 1 cc. must be added dropwise, with particular care to allow each drop to be fully decolorized before the next is introduced. The excess of permanganate solution necessary to give the end point color is determined by running a blank determination in another beaker containing the same volume of acid and water present in the original beaker, and heated to the same temperature (Note 30). The value of the permanganate solution in grams of CaO per cubic centimeter of solution may be calculated from the following equations:

$$5Na_2C_2O_4 + 2KMnO_4 + 8H_2SO_4 = 5Na_2SO_4 + K_2SO_4 + 2MnSO_4 + 10CO_2 + 8H_2O.$$

$$5CaC_2O_4 + 2KMnO_4 + 8H_2SO_4 = 5CaSO_4 + K_2SO_4 + 2MnSO_4 + 10CO_2 + 8H_2O.$$

NOTES.

1. Due to the rapidity with which quicklime and hydrated limes become contaminated by absorption of water and carbon dioxide from the air, samples must be protected in tightly stopped containers at all times. Samples for analysis are to be weighed from stoppered weighing bottles, the exact weight of the samples being determined by the difference in weight of the bottles before and after their removal.

2. Ignitions in electric muffles are far superior to flame ignitions. If an electric muffle is not available, flame ignition and the blast lamp may be used.

3. If a platinum dish is not available, porcelain may be used. A glass container positively must *not* be used.

4. Instead of strong acid, that of half strength may be used and the heating begun at once.

5. For ordinary control work in the plant laboratory this correction may, perhaps, be neglected; the double evaporation must never be neglected.

6. Fusion with pyrosulfate is to be avoided on account of the subsequent introduction of sulfates into the solution.

7. This precipitate may also contain TiO_2, P_2O_5, and Mn_3O_4.

8. Where the iron is present in small quantities it is rather unsatisfactory to determine it in the ignited oxides from the 0.5-g. sample. Under these conditions the alternative method may be used.

9. The pyrosulfates are less troublesome and more effective than the bisulfates.

10. This correction for impurities should not be made when the hydrofluoric acid correction of the main silica determination has been omitted. After two evaporations, 1 to 2 mg. of silica are still to be found with the R_2O_3 precipitate.

11. Zinc will also reduce titanium. If this metal is to be determined and deducted from Al_2O_3, then H_2S must be used for reduction (boiling out the H_2S in a stream of CO_2 before titration). If titanium is not to be determined, the slight error introduced by its reduction with zinc is so small as to be negligible except in the most exact and detailed analyses.

12. The gravimetric method must be employed when a recovery of aluminum is desired, or when a determination of strontium is contemplated.

13. Care must be exercised in this washing, as 1000 cc. of boiling water will dissolve over 1 cg. of CaC_2O_4.

14. The volumetric method may be used for ordinary control work in the plant laboratory. It must be borne in mind that in this method all strontium oxide is reported as calcium oxide.

15. Use not more than 125 cc. for this washing.

16. The less the amount of magnesium present, the longer the precipitate must be allowed to settle.

17. Made by diluting NH_4OH with distilled water until the solution contains $2\frac{1}{2}$ per cent NH_3 by weight. Three or four drops of HNO_3 (sp. gr. 1.42) are then added.

18 When manganese is present in the limestone, it will be caught in large part with the magnesium precipitate. (See U. S. Geological Survey *Bulletin 700*, p. 134.) In case manganese was not eliminated before this precipitation, the weighed pyrophosphate must be dissolved in HNO_3, tested for manganese with bismuthate, the manganese determined and deducted as $Mn_2P_2O_7$.

19. This determination may be made if desired upon the 0.5-g. sample ignited for solution in HCl. See first page of these methods under "Treatment of Sample."

20. A little bottle of 20 to 30-cc. capacity with glass stoppers, as described, ground to fit, is a convenient form of apparatus. (See Fig. 1.)

21. Boiling for one minute is usually sufficient.

22. In limestones very low in phosphorus it may be deemed desirable to concentrate the phosphorus from a considerable weight of sample. In this case, proceed as directed by F. Hinden (*Zeitschr. Anal. Chemie*, Vol. 54, p. 214 (1915)), as follows: To the nitric acid solution of the large sample add a few drops of Fe_2Cl_6 solution and then NH_4OH until the liquid becomes slightly turbid. Then add 0.5 g. of pure precipitated $CaCO_3$ and boil for five minutes. Filter, dissolve the precipitate in dilute HNO_3 and proceed as above.

23. Titanium and vanadium, which interfere in this determination, should not be encountered in appreciable amounts in this class of material.

Instead of the specified alkalimetric titration method, the phosphorus in the phosphomolybdate may be determined as magnesium pyrophosphate (U. S. Geological Survey *Bulletin 700*, pp. 178–179), or by the reductor method (A. A. Blair, "Chemical Analysis of Iron," 8th Edition, pp. 91–92).

24. The persulfate method may be employed if desired.

25. The separation of manganese with the R_2O_3 precipitate by the use of bromine is not recommended on account of the incompleteness of the precipitation. Separation of manganese by means of ammonium sulfide after the ammonia precipitation is also undesirable on account of the introduction of the reagent and the slimy character of the precipitate.

See also Note 18 concerning the contamination of magnesium pyrophosphate by manganese pyrophosphate and the need of corrective measures when manganese is present in the material under analysis.

26. With high calcium limes, more than 50 cc. of this solution will probably be required to titrate the liberated oxalic acid. In such cases the use of a larger burette is to be preferred to increasing the strength of the permanganate solution.

27. The siphon should not extend nearer than 1 in. from the bottom of the original bottle.

28. This solution should be standardized at least once every week. It will be found more convenient to make a solution as above described and standardize it every week, than to attempt, by boiling and filtering, to make a solution which will not change.

29. Sodium oxalate for standardization of potassium permanganate solution should be purchased from the U. S. Bureau of Standards, Washington, D. C. This material is sold by the Bureau of Standards as Sample No. 40a.

30. When the end point is reached, the temperature of the solution should not be below 60° C.

APPENDIX

ANALYSIS OF LIMESTONE OR LIME PRODUCTS

(Name of company)

Date.................................... Lab. No....................................

Name.................................... Date Rec'd....................................

Material....................................

Sample Marked....................................

CONSTITUENTS DETERMINED

Name	Formula	Per cent
Silica	SiO_2	
Iron oxide	Fe_2O_3	
Aluminum oxide	Al_2O_3	
Calcium oxide	CaO	
Magnesium oxide	MgO	
Total sulfur	S	
Sulfur trioxide	SO_3	
Phosphorus pentoxide	P_2O_5	
Carbon dioxide	CO_2	
Water, at 120° C	H_2O	
Water, total	H_2O	
Insoluble		
Loss on ignition		
Available lime		
Total neutralizing value in terms of $CaCO_3$, Calculated		
Total neutralizing value in terms of $CaCO_3$, Determined		
Plasticity		
Soundness		

CONSTITUENTS CALCULATED[a]

Name	Formula	Per cent
Calcium carbonate	$CaCO_3$	
Calcium hydroxide	$Ca(OH)_2$	
Magnesium carbonate	$MgCO_3$	
Magnesium hydroxide	$Mg(OH)_2$	
Calcium sulfate	$CaSO_4$	

[a] Method for calculation *must* be noted for each constituent.

SIEVE ANALYSIS

Sieve No.						
Opening in microns						
Per cent passing						

REMARKS

NOTE.—Unless otherwise noted all determinations have been made according to methods prescribed by the American Society for Testing Materials.

Signed....................................

TENTATIVE DEFINITIONS OF TERMS RELATING TO THE GYPSUM INDUSTRY[1]

Serial Designation: C 11 - 27 T

This is a **Tentative Standard**, published for the purpose of eliciting criticism and suggestions, and as such is subject to annual revision.

ISSUED, 1916; REVISED, 1921, 1922, 1923, 1924, 1925, 1926, 1927.

Aggregate.—Any inert material used as a filler in stucco, plaster, mortar, concrete, etc., without regard to its function as a binding material.

Consistency.—The degree of wetness of a plastic mixture.

Gypsum Molding Plaster.—A material consisting essentially of calcined gypsum for use in making interior embellishments, cornices, etc.

Gypsum Plaster Board.—A sheet composed of an incombustible core of gypsum, surfaced with paper or other fibrous material which is firmly bonded to the core, or with intermediate layers of such material within the core, or an incombustible sheet of gypsum with not more than 15 per cent by weight of fiber intimately mixed; and designed to be used as a lath for the reception of gypsum plaster.

Gypsum Pottery Plaster.—A material consisting essentially of calcined gypsum for use in making pottery, terra cotta and other ceramic molds.

Gypsum Wall Board.—A sheet composed of an incombustible core of gypsum, surfaced with paper or other fibrous material which is firmly bonded to the core, and designed to be used, without the addition of plaster, for walls, ceilings or partitions and affording a surface suitable to receive decoration.

Keene's Cement.—Anhydrous calcined gypsum, the set of which is accelerated by the addition of other materials.

Plasticity.—The yielding property of a wet mixture to change of form.

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[1] Criticisms of these Tentative Definitions are solicited and should be directed to Mr. H. J. Schweim, Secretary of Committee C-11 on Gypsum, The Gypsum Industries, 844 Rush St., Chicago, Ill.

These Definitions, when adopted as standard, will be added to the present Standard Definitions of Terms Relating to the Gypsum Industry (Serial Designation: C 11 - 26), 1927 Book of A.S.T.M. Standards, Part II.

TENTATIVE METHOD OF TEST

FOR

FIELD DETERMINATION OF APPROXIMATE APPARENT SPECIFIC GRAVITY OF FINE AGGREGATE[1]

Serial Designation: C 68 – 27 T

This is a **Tentative Standard,** published for the purpose of eliciting criticism and suggestions, and as such is subject to annual revision.

ISSUED, 1927.

Scope. 1. This method of test is intended for use in the field for making approximate determinations of the apparent specific gravity of fine aggregate.

Apparatus. 2. The apparatus shall consist of the following:

(*a*) *Balance.*—A balance, preferably of the torsion type, having a capacity of 2 kg. or more and sensitive to 0.5 g. or less.

(*b*) *Flask.*—A special graduated flask of the type, and conforming to the dimensions, shown in Fig. 1.

(*c*) *Chart.*—A chart for interpreting results, of the type shown in Fig. 2.

Sample. 3. A 1-kg. sample shall be selected which shall be as truly representative of the fine aggregate as possible. It shall be spread out on a flat surface and air dried until the surface moisture has evaporated and the sample is free flowing. The sample shall then be thoroughly mixed and 500 g. accurately weighed out.

Procedure. 4. The graduated flask shall be filled to the 200-cc. mark on the lower neck with water at room temperature. The 500-g. sample of fine aggregate shall then be slowly poured into the flask, and the flask and contents agitated while introducing the aggregate to free any entrained air bubbles. The combined volume in cubic centimeters of the water and fine aggregate shall be read on the scale on the upper neck of the flask.

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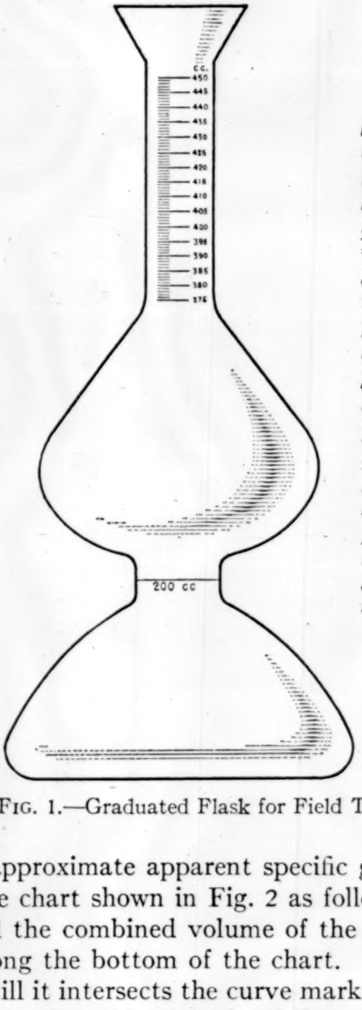
[1] Criticisms of this Tentative Method are solicited and should be directed to Mr. Stanton Walker, Secretary of Committee C-9 on Concrete and Concrete Aggregates, National Sand and Gravel Association, 837 Munsey Building, Washington, D. C.

Interpreting Results.

5. The approximate apparent specific gravity of the fine aggregate may be calculated from the formula:

$$\text{Approximate apparent specific gravity} = \frac{500}{V - 200}$$

where V = the combined volume in cubic centimeters of the water and fine aggregate in the flask.



Volume of lower chamber to mark on lower neck = 200 cc.

Combined volume of lower and upper chambers to lower end of graduated Scale on upper neck = 375 cc.

Scale graduated in 1cc. divisions from 375 cc. to 450 cc

Diameter of opening in lower neck, approximately $\frac{7}{8}$".

Diameter of bore of graduated upper neck, approximately $\frac{3}{4}$".

Diameter of base, approximately 4"

Diameter of funnel, approximately $1\frac{1}{2}$"

Range of use: From dry Sand of 2.8 sp. gr. to Sand of 2.2 sp. gr., having 10 per cent moisture

FIG. 1.—Graduated Flask for Field Testing of Fine Aggregate.

Or, the approximate apparent specific gravity may be found by the use of the chart shown in Fig. 2 as follows:

Find the combined volume of the mixture of fine aggregate and water along the bottom of the chart. Follow the vertical ordinate upward till it intersects the curve marked Specific Gravity—Volume. From this point of intersection follow the horizontal line to the right side of the chart and read the approximate apparent specific gravity of the fine aggregate.

Accuracy. 6. Duplicate determinations should check to within 0.05. Variations in the amount of water evaporated from the moist sample as described in Section 3 beyond the point at which the surface moisture has disappeared and the sample is free flowing and apparently dry will cause variations in results of from 0.5 to 1 per cent depending upon the absorption of the aggregate.

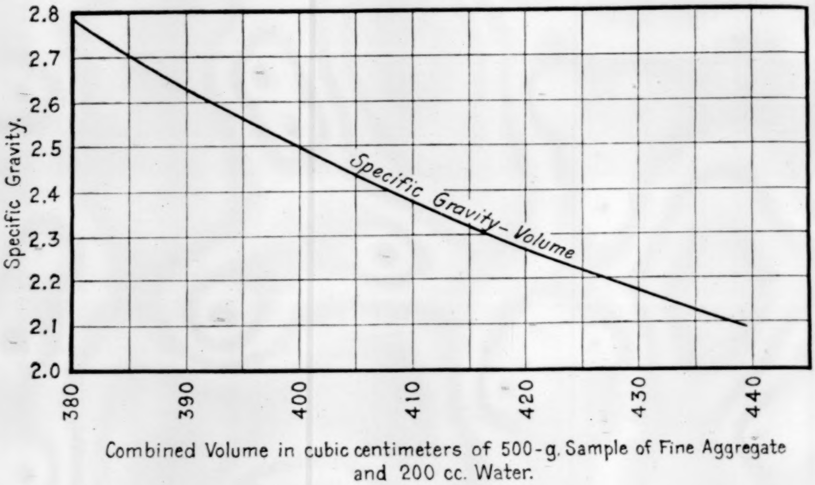


FIG. 2.—Chart for Determining Apparent Specific Gravity of Fine Aggregate.

TENTATIVE METHOD OF TEST
FOR
FIELD DETERMINATION OF APPROXIMATE PERCENTAGE OF VOIDS IN FINE AGGREGATE[1]

Serial Designation: C 69 - 27 T

This is a **Tentative Standard,** published for the purpose of eliciting criticism and suggestions, and as such is subject to annual revision.

Issued, 1927.

Scope. 1. This method of test is intended for use in the field for making approximate determinations of the percentage of voids in fine aggregate when inundated with water.

Apparatus. 2. The apparatus shall consist of the following:

(*a*) *Balance.*—A balance, preferably of the torsion type, having a capacity of 2 kg. or more and sensitive to 0.5 g. or less.

(*b*) *Flask.*—A special graduated flask of the type, and conforming to the dimensions, shown in Fig. 1.

(*c*) *Chart.*—A chart for interpreting results, of the type shown in Fig. 2.

Sample. 3. A sample weighing about 2 kg. shall be selected which shall be as truly representative of the fine aggregate as possible. It shall be well mixed and spread out on a flat surface and air dried until the surface moisture has evaporated and the sample is free flowing.

Procedure. 4. About 100 cc. of water shall be placed in the flask. Aggregate from the room-dry sample shall then be introduced slowly into the flask until the flask is filled to the 400-cc. mark on the upper neck. Water shall be added as required to keep the aggregate inundated as the filling proceeds. When the flask is filled to the 400-cc. mark, both water and aggregate shall be at the same level. The aggregate in the flask shall not be agitated during or after the filling operation. The flask and contents shall be weighed to the nearest gram, and the weight of the flask shall be deducted, unless its weight has been counter-balanced on the scale at the time of weighing.

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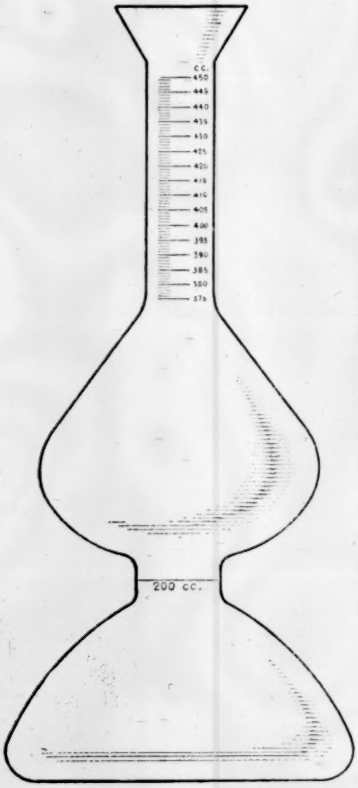
[1] Criticisms of this Tentative Method are solicited and should be directed to Mr. Stanton Walker, Secretary of Committee C-9 on Concrete and Concrete Aggregates, National Sand and Gravel Association, 837 Munsey Building, Washington, D. C.

Interpreting Results.

5. (*a*) This method requires that the apparent specific gravity be known of the fine aggregate in a room-dry, free flowing condition, but with the voids within the particles of the aggregate containing moisture. If the apparent specific gravity of the aggregate in this condition is not known it shall be determined in accordance with the Tentative Method of Test for Field Determination of Approximate Apparent Specific Gravity of Fine Aggregate (Serial Designation: C 68 – 27 T) of the American Society for Testing Materials.[1]



Volume of lower chamber to mark on lower neck = 200 cc.

Combined volume of lower and upper chambers to lower end of graduated Scale on upper neck = 375 cc.

Scale graduated in 1cc. divisions from 375 cc. to 450 cc.

Diameter of opening in lower neck, approximately $\frac{7}{8}$".

Diameter of bore of graduated upper neck, approximately $\frac{3}{4}$".

Diameter of base, approximately 4".

Diameter of funnel, approximately $1\frac{1}{2}$".

Range of use: From dry Sand of 2.8 sp. gr. to Sand of 2.2 sp. gr., having 10 per cent moisture.

FIG. 1.—Graduated Flask for Field Testing of Fine Aggregate.

(*b*) The approximate percentage of voids in the inundated fine aggregate may be calculated from the formula:

$$V = \frac{400 \times \text{sp. gr.} - W}{400\,(\text{sp. gr.} - 1)} \times 100$$

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[1] See p. 794.

where V = the approximate percentage of voids;
sp. gr. = apparent specific gravity of the fine aggregate;
W = combined weight in grams of 400 cc. of water and fine aggregate in the flask.

Or, the approximate percentage of voids may be found by the use of the chart shown in Fig. 2, as follows:

Find the combined weight of the fine aggregate and water along the bottom of the curve chart. Follow the vertical ordinate upward till it intersects the specific gravity line corresponding to that of the approximate apparent specific gravity of the fine aggregate under test. From this point of intersection follow the horizontal line to the left side of the chart and read the approximate percentage of voids in the sample.

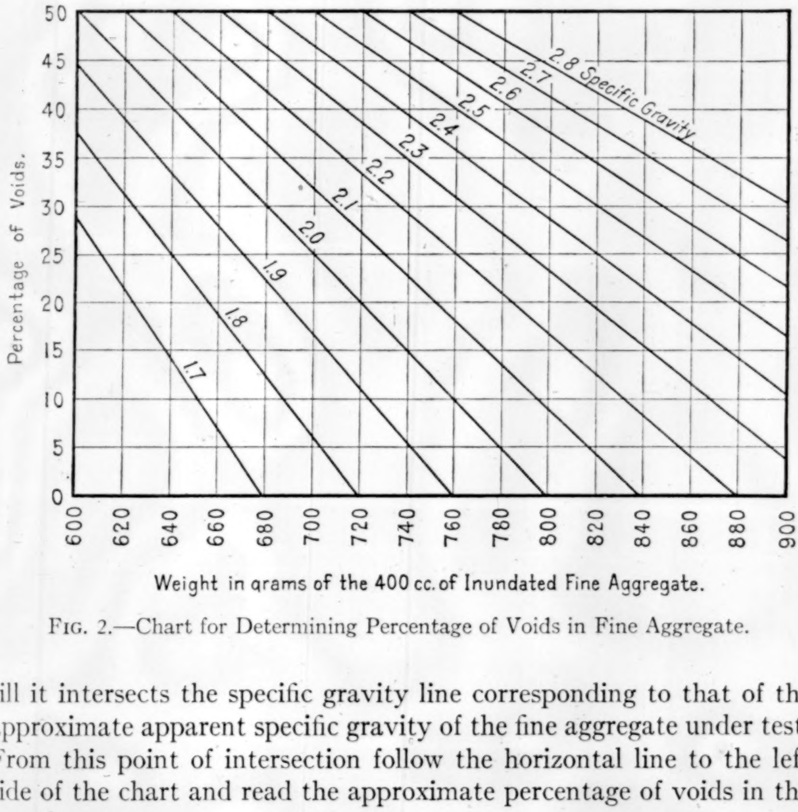

FIG. 2.—Chart for Determining Percentage of Voids in Fine Aggregate.

Accuracy. 6. Duplicate determinations should check to within 1 per cent. Variations in the composition of the rock grains of the fine aggregate which result in variations of 0.05 in the approximate apparent specific gravity of the aggregate will cause an inaccuracy in results equal to from 2 to 3 per cent of voids.

TENTATIVE METHOD OF TEST
FOR
FIELD DETERMINATION OF SURFACE MOISTURE IN FINE AGGREGATE[1]

Serial Designation: C 70 – 27 T

This is a **Tentative Standard,** published for the purpose of eliciting criticism and suggestions, and as such is subject to annual revision.

ISSUED, 1927.

Scope. 1. This method of test is intended for use in the field for making approximate determinations of the percentage of surface moisture in fine aggregate for use in computing the allowance to be made for water in the fine aggregate when proportioning concrete by the maximum water content method.

This method determines only surface moisture, that is, moisture on the outside of the particles. The moisture absorbed within the particles does not add to the volume of the particles and, therefore, does not make itself evident in this test.

Apparatus. 2. The apparatus shall consist of the following:

(*a*) *Balance.*—A balance, preferably of the torsion type, having a capacity of 2 kg. or more and sensitive to 0.5 g. or less.

(*b*) *Flask.*—A special graduated flask of the type, and conforming to the dimensions, shown in Fig. 1.

(*c*) *Chart.*—A chart for interpreting results, of the type shown in Fig. 2.

Sample. 3. A sample weighing about 1 kg. shall be selected which shall be as truly representative of the fine aggregate as possible. It shall be well mixed and spread out on a flat non-absorbent surface. Five hundred grams shall be immediately weighed out, permitting moisture to evaporate as little as possible from the sample.

Procedure. 4. The graduated flask shall be filled to the 200-cc. mark on the lower neck with water at room temperature. The 500-g. sample of damp aggregate shall then be slowly poured into the flask, and the contents of the flask agitated or stirred to free any entrained air bubbles. The combined volume, in cubic centimeters, of the water and fine aggregate shall be read on the scale on the upper neck of the flask.

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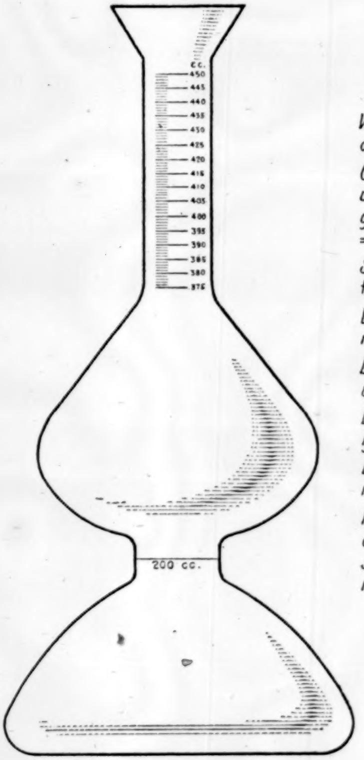
[1] Criticisms of this Tentative Method are solicited and should be directed to Mr. Stanton Walker, Secretary of Committee C-9 on Concrete and Concrete Aggregates, National Sand and Gravel Association, 837 Munsey Building, Washington, D. C.

Interpreting Results.

5. (*a*) This method requires that the apparent specific gravity be known of the fine aggregate in a room-dry, free flowing condition, but with the voids within the particles of the aggregate containing moisture. If the apparent specific gravity of the aggregate in this condition is not known it shall be determined in accordance with the Tentative Method of Test for Field Determination of Approximate Apparent Specific Gravity of Fine Aggregate (Serial Designation: C 68 - 27 T) of the American Society for Testing Materials.[1]



Volume of lower chamber to mark on lower neck = 200 cc.

Combined volume of lower and upper chambers to lower end of graduated Scale on upper neck = 375 cc.

Scale graduated in 1 cc. divisions from 375 cc. to 450 cc.

Diameter of opening in lower neck, approximately $\frac{7}{8}$".

Diameter of bore of graduated upper neck, approximately $\frac{3}{4}$".

Diameter of base, approximately 4".

Diameter of funnel, approximately $1\frac{1}{2}$"

Range of use: From dry Sand of 2.8 sp. gr. to Sand of 2.2 sp. gr., having 10 per cent moisture.

FIG. 1.—Graduated Flask for Field Testing of Fine Aggregate.

(*b*) The percentage of surface moisture in the fine aggregate (wet basis) may be calculated from the formula:

$$\text{Percentage of surface moisture} = \frac{V - \dfrac{500}{\text{sp. gr.}} - 200}{200 + 500 - V} \times 100$$

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[1] See p. 794.

where V = the combined volume in cubic centimeters of the water and fine aggregate in the flask;

sp. gr. = approximate apparent specific gravity of the fine aggregate.

Or, the percentage of surface moisture may be determined by the use of the chart shown in Fig. 2, as follows:

Find the combined volume of the mixture of fine aggregate and water along the bottom of the chart. Follow the vertical ordinate upward till it intersects the specific gravity line corresponding to the approximate apparent specific gravity of the fine aggregate under test. From this point of intersection follow the horizontal line to the left side of the chart and read the percentage of surface moisture in the fine aggregate.

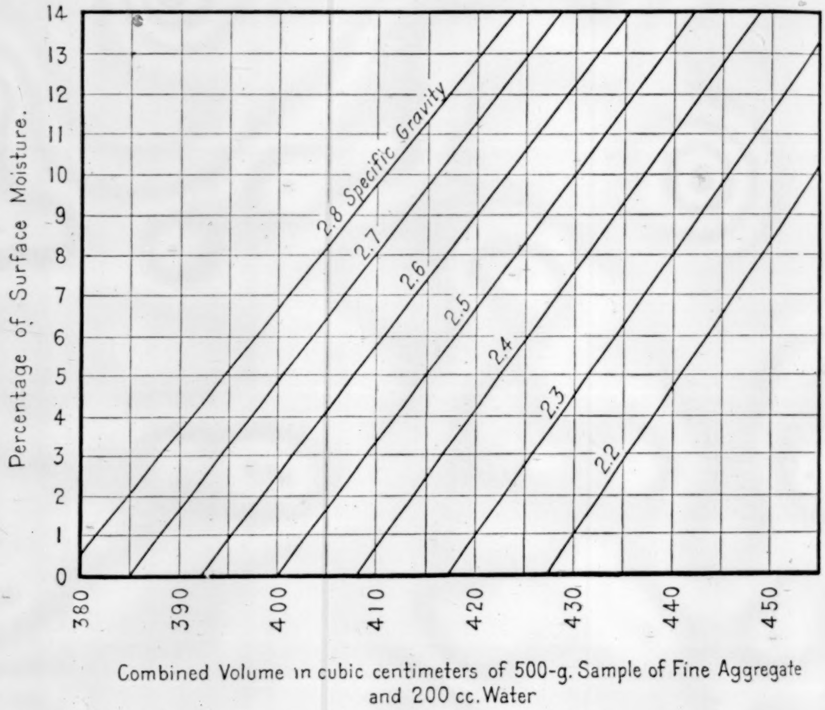

FIG. 2.—Chart for Determining Percentage of Surface Moisture in Fine Aggregate.

Accuracy. 6. Duplicate determinations should check to within 0.5 per cent. Variations in the composition of the rock grains of the fine aggregate which result in variations of 0.05 in the approximate apparent specific gravity of the aggregate will cause inaccuracy in results equal to from 1 to 1.5 per cent of moisture.

TENTATIVE SPECIFICATIONS
FOR
BUILDING BRICK
(MADE FROM CLAY OR SHALE)[1]

Serial Designation: C 62 – 27 T

This is a **Tentative Standard,** published for the purpose of eliciting criticism and suggestions, and as such is subject to annual revision.

ISSUED, 1927.

Scope.

1. These specifications cover building brick made from clay or shale and properly burned, suitable for use in the construction of buildings.

PHYSICAL PROPERTIES AND TESTS

Physical Properties and Tests.

2. (*a*) The bricks shall be classified as Grades *A*, *B*, and *C* on the basis of the following requirements. The classification of any lot of bricks shall be determined by the results of the tests for that requirement in which it is lowest, unless otherwise specified as provided in Section 8:

Name of Grade	Compressive Strength (bricks flatwise), lb. per sq. in.		Modulus of Rupture (bricks flatwise) lb. per sq. in.	
	Mean of 5 Tests	Individual Minimum	Mean of 5 Tests	Individual Minimum
Grade A	4500 or over	3500	600 or over	400
Grade B	2500–4500	2000	450 " "	300
Grade C	1250–2500	1000	300 " "	200

NOTE.—Bricks of Grades *A* and *B* are usually hard or well-burned. Bricks of Grade *C* are usually underburned.

(*b*) The tests shall be conducted in accordance with the Tentative Methods of Testing Brick (Serial Designation: C 67 – 27 T), of the American Society for Testing Materials.[2]

Test Specimens.

3. For the purpose of tests, bricks fairly representative of the commercial product shall be selected by a competent person appointed

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[1] Criticisms of these Tentative Specifications are solicited and should be directed to Mr. J. W. McBurney, Secretary of Committee C-3 on Brick, U. S. Bureau of Standards, Washington, D. C.

These Tentative Specifications are in effect a revision of the former Standard Specifications for Building Brick. The Standard Specifications, which were last published under the Serial Designation: C 21 – 24, have accordingly been withdrawn.

[2] See p. 826.

by the purchaser, the place or places of selection to be designated when the purchase order is placed. The manufacturer or seller shall furnish specimens for tests without charge. All bricks shall be carefully examined and their condition noted before testing. For the purpose of tests, not less than ten brick shall be required for each investigation. In general, two samples of ten brick each shall be tested for every 100,000 bricks contained in the lot under consideration; but where the total quantity exceeds 500,000, the number of samples tested may be fewer, provided that they shall be distributed as uniformly as practicable over the entire lot. Additional representative samples may be taken at any time or place at the discretion of the purchaser.

STANDARD SIZES

Standard Sizes.

4. The standard sizes shall conform to the following dimensions, with a permissible variation, plus or minus, of $\frac{1}{16}$ in. in depth, ⅛ in. in width, and ¼ in. in length:

Type	Depth, in.	Width, in.	Length, in.
Common brick	2¼	3¾	8
Rough-face brick	2¼	3¾	8
Smooth-face brick	2¼	3⅞	8

WORKMANSHIP AND FINISH

Surface Appearance.

5. When any particular surface appearance or uniformity is desired, it shall be as mutually agreed upon.

INSPECTION AND REJECTION

Visual Inspection.

6. All brick shall comply with the following requirements for general properties under visual inspection:

(*a*) They shall be free from cracks, warpage, stones, pebbles, or particles of lime that would affect their serviceability or strength.

(*b*) Bricks of Grades *A* or *B* when struck together shall give a ringing sound.

Rejection.

7. If the visual inspection, Section 6, appears to indicate inferior strength, the brick may be rejected unless the physical tests show the quality or grade to be as specified.

Acceptance.

8. At the option of the purchaser, acceptance may be based on the visual inspection requirements specified in Section 6 and the results of one of the strength tests (compression or flexure) specified in Section 2. While the compressive strength is considered as generally giving the better basis for classification purposes, the flexure test gives important information on the strength and proper manufacturing details.

TENTATIVE SPECIFICATIONS
FOR
PAVING BRICK[1]

Serial Designation: C 7 - 27 T

This is a **Tentative Standard,** published for the purpose of eliciting criticism and suggestions, and as such is subject to annual revision.

ISSUED, 1927.

Scope.

1. These specifications cover all styles of vitrified paving brick used in the construction of pavements, and classified as follows:

Class A: Vitrified Paving Brick.—The sizes and varieties recognized by the Permanent Committee on Simplification of Varieties and Styles for Vitrified Paving Brick of the U. S. Department of Commerce, as follows:

	DEPTH, IN.	WIDTH, IN.	LENGTH, IN.
Plain Wire-Cut (vertical fiber lugless as usually laid)	2½	4	8½
	3	4	8½
	3½	4	8½
Wire-Cut Lug (Dunn)	4	3½	8½
Repressed Lug	4	3½	8½

NOTE.—The above sizes and varieties are those recognized by the Permanent Committee, for the year 1927, and are subject to change from year to year.

Class B: Vitrified Paving Brick.—All other sizes and varieties.

Basis of Purchase.

2. The consumer or purchaser shall specify the class and variety or size, or the classes and varieties or sizes of paving brick to be supplied.

MANUFACTURE

Manufacture.

3. (*a*) Paving brick shall be manufactured from fire clay or shale, or a combination thereof.

(*b*) The material shall possess such physical and chemical properties that when molded into brick and properly vitrified, the resulting product will meet the requirements of these specifications.

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[1] Criticisms of these Tentative Specifications are solicited and should be directed to Mr. J. W. McBurney, Secretary of Committee C-3 on Brick, U. S. Bureau of Standards, Washington, D. C.

These tentative specifications, when adopted as standard, will supersede the present Standard Specifications for Paving Brick (Serial Designation: C 7 - 15), 1927 Book of A.S.T.M. Standards, Part II.

PHYSICAL PROPERTIES AND TESTS

Rattler Test. 4. (*a*) In addition to other tests mutually agreed upon, the quality and acceptability of paving brick, shall be determined by the Rattler Test, as described in the Tentative Methods of Testing Brick (Serial Designation: C 67 – 27 T) of the American Society for Testing Materials,[1] for the purpose of determining whether the brick possesses to a sufficient degree, strength, toughness, and hardness.

Visual Inspection. (*b*) A visual inspection shall be made for the purpose of determining whether the physical properties of the brick as to dimensions, accuracy, and uniformity of shape and color, are in general satisfactory as well as for the purpose of culling out from the shipment individually imperfect or unsatisfactory brick.

(*c*) The acceptance of paving brick as satisfactorily meeting one of these tests shall not be construed as in any way waiving the other.

Percentage of Loss. 5. The percentage of loss in the rattler test to be taken as the standard is not fixed in these specifications, and shall remain within the province of the contracting parties. For their information, the average percentage of loss as determined in accordance with the rattler test in the Tentative Methods of Testing Brick (Serial Designation: C 67 – 27 T) of the American Society for Testing Materials,[1] should not exceed 22 per cent for heavy-traffic brick and 24 per cent for light-traffic brick.

SAMPLING

Standard Test Sample. 6. The standard test sample of paving brick of any size shall be ten brick.

Place of Sampling. 7. In general, where a shipment of brick involving a quantity of less than 100,000 is under consideration, the sampling may be done either at the brick factory prior to shipment, on cars at their destination, or on the street when delivered ready for use. When the quantity under consideration exceeds 100,000, the sampling shall be done at the factory prior to shipment. Brick accepted as the result of test prior to shipment shall not be liable to subsequent rejection as a whole, but are subject to culling as specified in Section 13.

Selecting Samples. 8. In general, the buyer shall select his own samples from the material which the seller proposes to furnish. The seller shall have the right to be present during the selection of a sample. The sampler shall endeavor, to the best of his judgment, to select brick representing the average of the lot. No samples shall include bricks which would be rejected by visual inspection as provided in Section 13, except that where controversy arises, whole tests may be selected to determine the admissibility of certain varieties or portions of the lot having a characteristic appearance in common. In cases where prolonged controversy occurs between buyer and seller and samples selected by each party fail to show reasonable concurrence, then both parties shall agree on a disinterested person to select the samples, and both parties shall be bound by the results of tests made on samples thus selected.

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[1] See p. 826.

Number of Samples.

9. In general, one sample of ten brick shall be tested for every 10,000 bricks contained in the lot under consideration, but where the total quantity exceeds 100,000, the number of samples tested may be fewer than one per 10,000, provided that they shall be distributed as uniformly as practicable over the entire lot.

Shipment of Samples.

10. Samples which must be transported long distances by freight or express shall be carefully put in packages holding not more than twelve bricks each. When more than six bricks are shipped in one package, it shall be so arranged as to carry two parallel rows of bricks side by side, and these rows shall be separated by a partition. In the event of some of the bricks being cracked or broken in transit, the sample shall be disqualified if there are not remaining ten sound undamaged bricks.

Storage and Care of Samples.

11. Samples shall be carefully handled to avoid breakage or injury. They shall be kept in the dry so far as practicable. If they are wet when received, or known to have been immersed or subjected to recent prolonged wetting, they shall be dried for at least six hours at a temperature of 38° C. (100° F.) before testing.

SIZE AND PERMISSIBLE VARIATIONS

Size and Permissible Variations.

12. Paving brick shall conform to the following size requirements, subject to plus or minus variations of $\frac{1}{8}$ in. in width and depth, and $\frac{1}{2}$ in. in length:

	Depth, in.	Width, in.	Length, in.
Class B Brick			
Minimum	2	3	$8\frac{1}{2}$
Maximum	4	4	9
Class A Brick			
Minimum	$2\frac{1}{2}$	$3\frac{1}{2}$	$8\frac{1}{2}$
Maximum	4	4	$8\frac{1}{2}$

INSPECTION AND REJECTION

Inspection and Rejection.

13. It shall be the right of the buyer to inspect the bricks, subsequent to their delivery at the place of use, and prior to or during laying, to cull out and reject upon the following grounds:

(*a*) All brick which are broken in two or chipped in such a manner that neither wearing surface remains substantially intact, or that the lower or bearing surface is reduced in area by more than one-fifth. Where bricks are rejected upon this ground, it shall be the duty of the purchaser to use them in so far as practicable in obtaining the necessary half-bricks for breaking courses and making closures, instead of breaking otherwise whole and sound bricks for this purpose.

(*b*) All brick which are cracked in such a degree as to produce defects such as are defined in Paragraph (*a*), either from shocks received in shipment and handling, or from defective conditions of manufacture, especially in drying, burning or cooling, unless such cracks are plainly superficial and not such as to perceptibly weaken the resistance of the brick to its conditions of use.

(*c*) All brick which are so off-size, or so misshapen, bent, twisted or kiln-marked, that they will not form a proper surface as defined by the paving specifications, or align with other bricks without making joints other than those permitted in the paving specifications.

(*d*) All brick which are obviously too soft and too poorly vitrified to endure street wear. When any disagreement arises between the buyer and seller under this item, it shall be the right of the buyer to make two or more rattler tests of the brick, which he wishes to exclude, as provided in Section 4 (*a*) and if in either or both tests, the brick fall beyond the maximum rattler losses permitted under the specifications, then all brick having the same objectionable appearance may be excluded, and the seller shall pay the costs of the tests. But, if under such procedure, the bricks which have been tested as objectionable, shall pass the rattler test, the percentage of loss in both tests falling within the permitted maximum, then the buyer cannot exclude the class of material represented by this test and he shall pay the costs of the tests.

(*e*) All brick which differ so markedly in color from the type or average of the shipment, as to make the resultant pavement checkered or disagreeably mottled in appearance. This requirement shall not be held to apply to the normal variations in color which may occur in the product of one plant among brick which will meet the rattler test as provided in Section 14, but shall apply only to differences of color which imply differences in the material of which the bricks are made, or extreme differences in manufacture.

Rejection Limits.

14. (*a*) Paving brick shall not be judged for acceptance or rejection by the results of individual tests, but by the average of not less than five tests except that where a lot of brick fails to meet the required average, it shall be optional with the buyer whether the brick

shall be definitely rejected or whether they may be regraded and a portion selected for further test as provided in Paragraph (*c*).

(*b*) Some fluctuation in the results of the rattler test, both on account of variations in the bricks and in the machine used in testing, are unavoidable and a reasonable allowance for such fluctuation should be made, wherever the standard may be fixed.

(*c*) In any lot of paving brick, if the percentage of loss on a test computed upon its initial weight exceeds the specified loss by more than 2 per cent, then the portion of the lot represented by that test shall at once be re-sampled and three more tests made; and if any of these three tests shall again exceed by more than 2 per cent the specified loss then that portion of the lot shall be rejected.

If, in any lot of brick, the results of two or more tests exceed the permissible maximum, then the buyer may, at his option, reject the entire lot, even though the average of all the tests executed may be within the required limits.

(*d*) Where a lot, or portion of a lot of brick is rejected, either by reason of failure to show a low enough average test or because of tests above the permissible maximum, the buyer may, at his option, permit the seller to regrade the rejected brick, separating out that portion which he considers at fault and retaining that which he considers good. When the regrading is complete, the good portion shall be then re-sampled and retested, under the original conditions, and if it fails again either in average or in permissible maximum, then the buyer may definitely and finally reject the entire lot or portion under test.

Payment of Test Costs.

15. Unless otherwise specified, the cost of testing the material as delivered or prepared for delivery, up to the prescribed number of tests for valid acceptance or rejection of the lot, shall be paid by the buyer. The cost of testing extra samples made necessary by the failure of the whole lot or any portion of it, shall be paid by the seller, whether the material is finally accepted or rejected.

TENTATIVE SPECIFICATIONS
FOR
CLAY FIRE BRICK FOR MALLEABLE FURNACES WITH REMOVABLE BUNGS AND FOR ANNEALING OVENS[1]

Serial Designation: C 63 – 27 T

This is a **Tentative Standard,** published for the purpose of eliciting criticism and suggestions, and as such is subject to annual revision.

ISSUED, 1927.

Purpose and Utility of Specifications.—The purpose of these specifications is the selection of clay fire brick that are suitable for service in malleable furnaces under general conditions of operation and of furnace design. However, use of these specifications shall not relieve the buyer of all responsibility in the selection of the refractories best suited for his particular practice. Of the brands which may meet the requirements some will give better service than others. One brand may give best results in one plant, and a second brand in another plant; and a given brand may give highly satisfactory results in one plant, and fail to do so in another. The reason for this variability in results lies in the almost countless combinations of conditions which exist in plant operation. Some of the factors which directly or indirectly effect the life of the brick are the following:

A. FACTORS DEPENDENT UPON FUEL OR FIRING:
  Character and kind of fuel;
  Character of ash or fluxing ingredients;
  Quantity of ash or fluxing ingredients;
  Method of firing;
  Character of blast and length of flame;
  Pressure of blast;
  Direction of flame and impinging of flame upon brickwork.

B. FACTORS DEPENDENT UPON FURNACE DESIGN OR CONSTRUCTION:
  Rise and span of arch;
  Type of bung frame;
  Care taken and method followed in laying brick and building bungs;
  Tightness with which brick are clamped in bung frames;
  Kind of clay used in laying brick;
  Thickness of walls.

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[1] Criticisms of these Tentative Specifications are solicited and should be directed to Mr. L. J. Trostel, Secretary of Committee C-8 on Refractories, General Refractories Co. Laboratories, P. O. Box 935, Baltimore, Md.

C. FACTORS DEPENDENT UPON CHARACTER OF CHARGE:

Kind and amount of scrap used;
Amount of foreign material and rust on scrap;
Percentage of pig in charge.

D. FACTORS DEPENDENT UPON OPERATING CONDITIONS:

Method of charging;
Operating temperature;
Duration of melting period;
Size of heats and number of heats per day;
Care taken and method followed in handling bungs;
Positions of brick in furnace and practice followed in shifting bungs.

These specifications do not include a requirement for slag resistance, although evidence indicates that the brick, and especially the sidewall brick, should be resistant to the corrosive action of slag. In the light of present knowledge, however, none of the slag tests that have been proposed can be regarded as satisfactory for malleable furnace service.

The bungs and sidewalls must withstand high operating temperatures. This is ensured by the softening point requirement. They must be resistant to rapid temperature changes, hence the spalling test requirement. The spalling requirements for sidewalls have been made less stringent than for bungs, as the spalling conditions are less severe. Sidewall brick must also withstand slag action at the slag line and the brick which are most resistant to slagging do not usually withstand spalling to the highest degree. Practical experience has shown that in bungs and sidewall brick the silica content should not be excessively high. This is cared for by imposing a maximum limit on the percentage of silica. A minimum limit is placed upon the cold breaking strength, merely to ensure that the bung brick shall be strong enough to withstand clamping in the bung frames, and to withstand shipping and handling without excessive scuffing. It is recognized that high strength is not necessarily desirable.

Revision of the requirements is to be expected as methods of testing are further perfected, and as the effect of operating conditions upon the life of the brick becomes better understood. Clay fire brick which fail to meet the requirements of these specifications may be regarded as unsatisfactory for general malleable furnace and annealing oven service.

Scope.

1. These specifications are intended to cover only burned products made from fire clay by the usual processes of manufacture and containing not more than 55 per cent alumina or 85 per cent silica. Even within this range of composition, it is not intended to include products other than those regularly sold as clay fire brick.

SIZE TOLERANCE

Permissible Variations.

2. Variations (plus or minus) of 2 per cent from specified dimensions covering both shrinkage and warpage shall be allowed on dimensions of 4 in. or over. On dimensions under 4 in., 3 per cent variation shall be allowed.

TEST REQUIREMENTS

Malleable Furnace Bungs:

Test Requirements.

3. (*a*) *Silica Content.*—The silica content shall not exceed 65 per cent.

(*b*) *Softening Point.*—The softening point shall not be below cone 31.

(*c*) *Spalling.*—Brick as shipped, after subjection to an average of 18 dips in the spalling test, as described in Section 11, shall not show a loss of more than 20 per cent of their original weights.

(*d*) *Modulus of Rupture.*—The modulus of rupture of the brick tested cold shall not be less than 200 lb. per sq. in.

Malleable Furnace Sidewalls and Bridgewalls:

Test Requirements.

4. (*a*) *Silica Content.*—The silica content shall not exceed 65 per cent.

(*b*) *Softening Point.*—The softening point shall not be below cone 31.

(*c*) *Spalling.*—Brick as shipped, after subjection to an average of 9 dips in the spalling test, as described in Section 11, shall not show a loss of more than 20 per cent of their original weights.

(*d*) *Linear Change.*—When duplicate samples are heated uniformly to a temperature of 1400° C., maintained at this temperature for 5 hours and cooled, they shall not show a contraction of more than 1.5 per cent of the original length.

Malleable Furnace Firebox Linings and Lower Stack Linings:

Test Requirements.

5. (*a*) *Softening Point.*—The softening point shall not be below cone 31 in the case of the non-siliceous grade[1] and not below cone 28 in the case of the siliceous grade.[1]

(*b*) *Linear Change.*—When duplicate samples are heated uniformly to a temperature of 1400° C., maintained at this temperature for 5 hours and cooled, they shall not show a contraction of more than 1.5 per cent of the original length.

Malleable Furnace Upper Stack Lining:

Test Requirements.

6. (*a*) *Softening Point.*—The softening point shall not be below cone 28.

(*b*) *Linear Change.*—When duplicate samples are heated uniformly to a temperature of 1350° C., maintained at this temperature for 5 hours and cooled, they shall not show an average contraction of more than 1.5 per cent of the original length.

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[1] Brick are considered as being of siliceous grade when the silica content is greater than 65 per cent and of non-siliceous grade when the silica content is 65 per cent or less.

Annealing Oven Firebox:

Test Requirements. 7. For annealing-oven firebox service the test requirements shall conform to those specified for firebox linings of malleable furnaces in accordance with Section 5.

Annealing Oven Chamber:

Test Requirements. 8. (*a*) *Softening Point.*—The softening point shall not be below cone 16.

(*b*) *Linear Change.*—When duplicate samples are heated uniformly to a temperature of 1150° C., maintained at this temperature for 5 hours and cooled, they shall not show a contraction of more than 1.5 per cent of the original length.

METHODS OF TESTING

Silica Content. 9. The determination of silica content shall be made in accordance with the analytical methods described in the Standard Methods of Ultimate Chemical Analysis of Refractory Materials, Including Chrome Ores and Chrome Brick (Serial Designation: C 18) of the American Society for Testing Materials.[1]

Softening Point. 10. (*a*) The softening point shall be determined in accordance with the Standard Method of Test for Softening Point of Fire-Clay Brick (Serial Designation: C 24) of the American Society for Testing Materials.[1]

(*b*) In the event that the material fails to pass the specified requirements by one cone or less, two additional softening point determinations shall be made as checks on the accuracy of the test and the final results judged on the basis of the three determinations. This procedure is necessary because of variations that have been found to exist in this test even where the standard methods are followed.

Spalling Test. 11. (*a*) The spalling test shall be made on standard 9-in. straight brick, or standard 9-in. or 13-in. bung brick.

(*b*) The spalling test shall be conducted in accordance with the Tentative Method of Test for Resistance of Fire-Clay Brick to Thermal Spalling Action (Serial Designation: C 38 - 27 T) of the American Society for Testing Materials[2] (Note 1). The test shall be continued until each brick shall have lost 20 per cent by weight or until the total number of immersions necessary to give the required average has been obtained. Individual samples shall not be continued in the test after a loss of 20 per cent has been sustained. The brick shall be dried and weighed before and after testing and the loss computed as a percentage of the original dry weight.

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[1] 1927 Book of A.S.T.M. Standards, Part II.

[2] See p. 837.

(*c*) The results in the spalling test for any one brand shall be reported as the average loss of 10 specimens selected at random. If desired, the test may be made on only 5 specimens, but when this is done 5 additional specimens shall be tested in the event that the first 5 do not meet the requirements, and the results reported as the average of the entire 10.

Modulus of Rupture.

12. (*a*) The modulus of rupture shall be determined in accordance with the method of test for modulus of rupture of building brick, as described in Sections 8 to 12 of the Tentative Methods of Testing Brick (Serial Designation: C 67 – 27 T) of the American Society for Testing Materials.[1]

(*b*) The results in the modulus of rupture test for any one brand shall be reported as the average of 10 specimens selected at random. If desired, the test may be made on only 5 specimens, but when this is done an additional 5 specimens shall be tested in the event that the first 5 do not meet the requirements, and the results reported as the average of the entire 10.

EXPLANATORY NOTE

NOTE 1.—It will be noted that the present Tentative Method of Test for Resistance of Fire-Clay Brick to Thermal Spalling Action (C 38 – 27 T) of the American Society for Testing Materials is the one referred to in these specifications. It is recognized that there are other methods which have much to commend them; the 850° C. water dip spalling test developed at the Bureau of Standards; the air spalling test used by a large contracting company; and possibly others. It seems very probable however, in the light of past work and that now going on, that the ultimate spalling test may be different from any of these. Everything considered, it seems best to use Method C 38 for the present.

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[1] See p. 826.

TENTATIVE SPECIFICATIONS
FOR
CLAY FIRE BRICK FOR STATIONARY BOILER SERVICE[1]

Serial Designation: C 64 - 27 T

This is a Tentative Standard, published for the purpose of eliciting criticism and suggestions, and as such is subject to annual revision.

ISSUED, 1927.

Purpose and Utility of Specifications.—The purpose of these specifications is the selection of clay fire brick for general boiler service. They may not apply to the special conditions sometimes encountered in high-power utility boilers. In these plants general conditions may not apply and the selection of the refractories often becomes a special problem for the particular plant involved.

Use of these specifications will not relieve the buyer of all responsibility in the selection of the refractories best suited to his particular practice. Of the brands which meet these requirements, some may give highly satisfactory service in one installation and fail to do so in another. Certain brands may give best service in one plant, other brands in another plant. The reason for this variability in service lies in the almost countless combinations of conditions which may exist in boiler furnace operation. Some of the factors which directly or indirectly affect the life of the brick are the following:

A. FACTORS DEPENDENT UPON DESIGN OR CONSTRUCTION OF THE SETTING:
- Furnace volume;
- Thickness and height of walls;
- Use of relieving arches or sectional wall supports;
- Degree of insulation;
- Provision for air or water cooling of refractories;
- Type of stoker arch;
- Height of stoker arch above grates or stoker;
- Provision for expansion of the brickwork;
- Care taken and method followed in laying brick;
- Character of mortar used in laying brick.

B. FACTORS DEPENDENT UPON FUEL AND FIRING:
- Hand or mechanical firing;
- Type of grate, stoker or burner;
- Character and kind of fuel;
- Direction of flame and impingement on brickwork;
- Character of ash or fluxing ingredients;
- Quantity of ash or fluxing ingredients;
- Fusibility and viscosity of ash.

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[1] Criticisms of these Tentative Specifications are solicited and should be directed to Mr. L. J. Trostel, Secretary of Committee C-8 on Refractories, General Refractories Co. Laboratories, P. O. Box 935, Baltimore, Md.

C. FACTORS DEPENDENT UPON OPERATION:

Air leaks in furnace walls;
Temperature of operation;
Care and promptness in cleaning boiler tubes;
Continuity of operation;
Character of furnace atmosphere;
Violence of temperature fluctuations;
Rate of operation;
Segregation of different sizes of coal on chain grates;
Pressure or draft conditions in furnace;
Care and promptness of making minor repairs;
Method of removing adhering clinker;
Abrasion of brickwork.

In these specifications brick are divided into siliceous and non-siliceous grades, but no other definite requirement is stipulated as to analysis, as no definite relationship between analysis and service has been demonstrated. The softening point requirements are well above the temperatures actually attained by the brickwork in general boiler practice.

The most important causes of failure are spalling and slag action. The spalling test specified will select brick of satisfactory resistance to thermal shock for general boiler practice. In those installations where exceptionally severe spalling seems to occur, the failure of the brick may in many cases be the result of factors which cannot be measured in the spalling test. Such conditions call for study by a competent engineer.

Brick which are subjected to severe slagging conditions in service should not be required to meet a severe spalling test requirement. Although slagging is one of the major causes of failure of the refractories, no test for slag resistance is included in these specifications for the reason that in the light of present knowledge none of the methods of making slag tests that have been proposed can be regarded as satisfactory.

Revision of the requirements is to be expected as methods of testing are further perfected, and as the effect of operating conditions upon the life of the brick becomes better understood. However, clay fire brick which fail to meet the requirements of these specifications may be regarded as unsatisfactory for general boiler service.

Scope. 1. These specifications are intended to cover only burned products made from fire clay by the usual processes of manufacture and containing not more than 55 per cent alumina or 85 per cent silica. Even within this range of composition, it is not intended to include products other than those regularly sold as clay fire brick.

SIZE TOLERANCE

Permissible Variations. 2. Variations (plus or minus) of 2 per cent from specified dimensions covering both shrinkage and warpage shall be allowed on dimensions of 4 in. or over. On dimensions under 4 in., 3 per cent variation shall be allowed.

TEST REQUIREMENTS

Moderate Heat Duty Boiler Settings

3. The requirements for brick for moderate high duty boiler settings are intended to apply to boiler furnaces in which the temperatures are not over 2400° F. (1315° C.).

A. *Zone of Highest Temperatures* (sidewalls, arches, doors, and jambs):

Test Requirements.

4. (*a*) *Softening Point.*—The softening point shall not be below cone 29 in the case of the non-siliceous grade[1] and not below cone 27 in the case of the siliceous grade.[1]

(*b*) *Linear Change.*—When duplicate samples are heated uniformly to a temperature of 1350° C., maintained at this temperature for 5 hours and cooled, they shall not show an average contraction of more than 1.5 per cent of the original length.

B. *Zone of Lower Temperatures* (backing-up brick for highest temperature zone, and walls beyond first tube bank):

Test Requirements.

5. (*a*) *Softening Point.*—The softening point shall not be below cone 18.

(*b*) *Modulus of Rupture.*—The modulus of rupture of the brick tested cold shall not be under 500 lb. per sq. in.

High Heat Duty Boiler Settings

A. *Zone of Highest Temperatures* (sidewalls, bridgewalls, arches, doors and jambs; and first pass sidewalls):

Test Requirements.

6. The requirements for brick for zone of highest temperatures in high heat duty boiler settings are intended to apply to boiler furnaces in which the temperature of the combustion chamber is continuously, or a significant portion of the time, above 2400° F. (1315° C.) under normal conditions of operation. The refractoriness of the non-siliceous grade is assured by the softening point, but for this requirement in the case of the siliceous grade it is necessary to incorporate both the softening point and load test.

Test Requirements.

7. (*a*) *Softening Point.*—The softening point shall not be below cone 31 in the case of the non-siliceous grade and not below cone 28 in the case of the siliceous grade.

(*b*) *Linear Change.*—When duplicate samples are heated uniformly to a temperature of 1400° C., maintained at this temperature for 5 hours and cooled, they shall not show an average contraction of the original length of more than 1.5 per cent in the case of the non-siliceous grade and 0.75 per cent in the case of the siliceous grade.

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[1] Brick are considered as being of siliceous grade when the silica content is greater than 65 per cent and of non-siliceous grade when the silica content is 65 per cent or less.

(*c*) *Spalling.*—When subjected to the spalling test, brick shall withstand an average of 5 dips in the case of the non-siliceous grade and 3 dips in the case of the siliceous grade.

(*d*) *Deformation.*—Deformation in the standard load test at 1350° C. under a load of 25 lb. per sq. in. shall not be over 6 per cent in the case of the siliceous grade.

Service Condition No. 1.

8. *Service Condition No. 1.*—For division walls heated on both sides, the following requirements shall apply:

(*a*) *Softening Point.*—The softening point shall not be below cone 31 in the case of the non-siliceous grade and not below cone 28 in the case of the siliceous grade.

(*b*) *Deformation.*—Deformation in the standard load test at 1350° C. under a load of 25 lb. per sq. in. shall not be over 6 per cent in the case of the non-siliceous grade and not over 4 per cent in case of the siliceous grade.

NOTE.—It is not practical to include a spalling test for brick subject to rigid load test requirements.

Service Condition No. 2.

9. *Service Condition No. 2.*—Under severe conditions of spalling, the following requirements shall apply:

(*a*) *Softening Point.*—The softening point shall not be below cone 31 in the case of the non-siliceous grade and not below cone 28 in the case of the siliceous grade.

(*b*) *Linear Change.*—When duplicate samples are heated uniformly to a temperature of 1400° C., maintained at this temperature for 5 hours and cooled, they shall not show an average contraction of the original length of more than 2 per cent in the case of the non-siliceous grade and 1 per cent in the case of the siliceous grade.

(*c*) *Spalling.*—When subjected to the spalling test, brick shall withstand an average of 9 dips in the case of the non-siliceous grade and 4 dips in the case of the siliceous grade.

NOTE.—It is not practical to include a limit for deformation under load, since fire-clay brick which are so made as to give the highest resistance to spalling are relatively weak under load.

Service Condition No. 3.

10. *Service Condition No. 3.*—For service where slagging conditions are severe, the following requirements shall apply:

(*a*) *Softening Point.*—The softening point shall not be below cone 31 in the case of the non-siliceous grade and not below cone 28 in the case of the siliceous grade.

(*b*) *Linear Change.*—When duplicate samples are heated uniformly to a temperature of 1400° C., maintained at this temperature for 5 hours and cooled, they shall not show an average contraction of the original length of more than 1 per cent in the case of the non-siliceous grade and 0.5 per cent in the case of the siliceous grade.

(*c*) *Water Absorption.*—Water absorption shall not be over 10 per cent in the case of the non-siliceous grade and 18 per cent in the case of the siliceous grade.

NOTE.—These tests are specified for conditions of severe slag erosion to insure good refractoriness and high density, as these properties are known to be important. No slag test has been devised which gives quantitative results that can be used in specifications.

11. When any one of the three special service conditions described in Sections 8, 9 and 10 is to be met, it shall be expressly stipulated by the purchaser.

B. Zone of Lower Temperatures (backing-up brick for highest temperature zone, and walls of second and third passes):

Test Requirements.

12. The service to which brick in the zone of lower temperatures are subjected varies with the size and type of boiler, thickness of walls, degree of insulation, draft conditions and position in the furnace. Leaky baffles may sometimes cause the brick beyond the first tube bank to be subjected to unexpectedly high temperatures. Depending upon the particular conditions, and upon the margin of safety desired, the brick used may be of the same grade as used in the zone of highest temperatures as described in Section 7, or of one of the following grades:

	GRADE A	GRADE B	GRADE C
Softening point, not under................	cone 28	cone 26	cone 18
Modulus of rupture, lb. per sq. in., not under	450	500	500

METHODS OF TESTING

Silica Content.

13. The determination of silica content shall be made in accordance with the analytical methods described in the Standard Methods of Ultimate Chemical Analysis of Refractory Materials, Including Chrome Ores and Chrome Brick (Serial Designation: C 18) of the American Society for Testing Materials.[1]

Softening Point.

14. (*a*) The softening point (fusion point) shall be determined in accordance with the Standard Method of Test for Softening Point of Fire-Clay Brick (Serial Designation: C 24) of the American Society for Testing Materials.[1]

(*b*) In the event that the material fails to pass the specified requirements by one cone or less, two additional softening point determinations shall be made as checks on the accuracy of the test and the final results judged on the basis of the three determinations. This procedure is necessary because of variations that have been found to exist in this test even where the standard methods are followed.

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[1] 1927 Book of A.S.T.M. Standards, Part II.

Spalling Test.

15. (*a*) The spalling test shall be conducted in accordance with the Tentative Method of Test for Resistance of Fire-Clay Brick to Thermal Spalling Action (Serial Designation: C 38 – 27 T) of the American Society for Testing Materials[1] (Note 1). The test shall be continued until each brick shall have lost 20 per cent by weight or until the total number of immersions necessary to give the required average has been obtained. Individual samples shall not be continued in the test after a loss of 20 per cent has been sustained. The brick shall be dried and weighed before and after testing and the loss computed as a percentage of the original dry weight.

(*b*) The results in the spalling test for any one brand shall be reported as the average loss of 10 specimens selected at random. If desired, the test may be made on only 5 specimens, but when this is done an additional 5 specimens shall be tested in the event that the first 5 do not meet the requirements, and the results reported as the average of the entire 10.

Modulus of Rupture.

16. (*a*) The modulus of rupture shall be determined in accordance with the method of test for modulus of rupture of building brick, as described in Sections 8 to 12 of the Tentative Methods of Testing Brick (Serial Designation: C 67 – 27 T) of the American Society for Testing Materials.[2]

(*b*) The results in the modulus of rupture test for any one brand shall be reported as the average of 10 specimens selected at random. If desired, the test may be made on only 5 specimens, but when this is done an additional 5 specimens shall be tested in the event that the first 5 do not meet the requirements, and the results reported as the average of the entire 10.

Load Test.

17. The load test shall be made in accordance with the Standard Method of Test for Refractory Materials Under Load at High Temperatures (Serial Designation: C 16) of the American Society for Testing Materials.[3]

EXPLANATORY NOTE

NOTE 1.—It will be noted that the present Tentative Method of Test for Resistance of Fire-Clay Brick to Thermal Spalling Action (C 38 – 27 T) of the

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[1] See p. 837.

[2] See p. 826.

[3] 1927 Book of A.S.T.M. Standards, Part II.

American Society for Testing Materials is the one referred to in these specifications. It is recognized that there are other methods which have much to commend them; the 850° C. water dip spalling test developed at the Bureau of Standards; the air spalling test used by a large contracting company; and possibly others. It seems very probable however, in the light of past work and that now going on, that the ultimate spalling test may be different from any of these. Everything considered it seems best to use Method C 38 for the present.

TENTATIVE SPECIFICATIONS
FOR
CLAY FIRE BRICK FOR MARINE BOILER SERVICE[1]

Serial Designation: C 65 – 27 T

This is a **Tentative Standard,** published for the purpose of eliciting criticism and suggestions, and as such is subject to annual revision.

ISSUED, 1927.

Purpose and Utility of Specifications.—The purpose of these specifications is the selection of clay fire brick for marine boiler service.

Use of these specifications will not relieve the buyer of all responsibility in the selection of the refractories best suited to his particular practice. They may not apply to certain extreme conditions encountered in unusual settings. Of the brands which meet these requirements, some may give highly satisfactory service in one installation and fail to do so in another. Certain brands may give best service in one type of vessel, other brands in another type. The reason for this variability in service lies in the almost countless combinations of conditions which may exist in marine-boiler furnace operation. Some of the factors which directly or indirectly affect the life of the brick are the following:

A. FACTORS DEPENDENT UPON DESIGN OR CONSTRUCTION OF THE SETTING:
- Furnace volume;
- Thickness and height of walls;
- Degree of insulation;
- Provision for air or water cooling of refractories;
- Type of stoker arch;
- Height of stoker arch above grates or stoker;
- Care taken and method followed in laying brick;
- Character of mortar used in laying brick.

B. FACTORS DEPENDENT UPON FUEL AND FIRING:
- Hand or mechanical firing;
- Type of grate, stoker or burner;
- Character and kind of fuel;
- Direction of flame and impingement on brickwork;
- Character of ash or fluxing ingredients;
- Quantity of ash or fluxing ingredients;
- Fusibility and viscosity of ash.

C. FACTORS DEPENDENT UPON OPERATION:
- Vibration and shocks;
- Air leaks in furnace walls;

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[1] Criticisms of these Tentative Specifications are solicited and should be directed to Mr. L. J. Trostel, Secretary of Committee C-8 on Refractories, General Refractories Co. Laboratories, P. O. Box 935, Baltimore, Md.

Temperature of operation;
Care and promptness in cleaning boiler tubes;
Continuity of operation;
Character of furnace atmosphere;
Violence of temperature fluctuations;
Rate of operation;
Pressure or draft conditions in furnace;
Care and promptness of making minor repairs;
Method of removing clinker;
Abrasion of brickwork.

The most important causes of failure are softening (fusion), spalling, slag action, and shrinkage. The softening point requirements are well above the temperatures actually attained by the brickwork in marine boiler practice. The spalling test specified will select brick of satisfactory resistance to thermal shock for this class of service. In those installations where exceptionally severe spalling seems to occur, the failure of the brick may in many cases be the result of factors which cannot be measured in the spalling test. Such conditions call for study by a competent engineer.

Brick which are subjected to severe slagging conditions in service should not be required to meet a severe spalling test requirement. Although slagging is one of the major causes of failure of the refractories, no test for slag resistance is included in these specifications for the reason that in the light of present knowledge none of the methods of making slag tests that have been proposed can be regarded as satisfactory.

Revision of the requirements is to be expected as methods of testing are further perfected, and as the effect of operating conditions upon the life of the brick becomes better understood. However, clay fire brick which fail to meet the requirements of these specifications may be regarded as unsatisfactory for marine boiler service.

Scope.

1. These specifications are intended to cover only burned products made from fire clay by the usual processes of manufacture and containing not more than 55 per cent alumina or 85 per cent silica. Even within this range of composition, it is not intended to include products other than those regularly sold as clay fire brick.

SIZE TOLERANCE

Permissible Variations.

2. Variations (plus or minus) of 2 per cent from specified dimensions covering both shrinkage and warpage shall be allowed on dimensions of 4 in. or over. On dimensions under 4 in., 3 per cent variation shall be allowed.

TEST REQUIREMENTS

Moderate Heat Duty Boiler Settings

Test Requirements.

3. (*a*) *Softening Point.*—The softening point shall not be below cone 29 in the case of the non-siliceous[1] grade and not below cone 27 in the case of the siliceous grade.[1]

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[1] Brick are considered as being of siliceous grade when the silica content is greater than 65 per cent and of non-siliceous grade when the silica content is 65 per cent or less.

(*b*) *Linear Change.*—When duplicate samples are heated uniformly to a temperature of 1350° C., maintained at this temperature for 5 hours and cooled, they shall not show an average contraction of more than 1.5 per cent of the original length.

High Heat Duty Boiler Settings

Test Requirements.

4. (*a*) *Softening Point.*—The softening point shall not be below cone 31 in the case of the non-siliceous grade and not below cone 28 in the case of the siliceous grade.

(*b*) *Linear Change.*—When duplicate samples are heated uniformly to a temperature of 1400° C., maintained at this temperature for 5 hours and cooled, they shall not show an average contraction of the original length of more than 1.5 per cent in the case of the non-siliceous grade and 0.75 per cent in the case of the siliceous grade.

(*c*) *Spalling.*—When subjected to the spalling test brick shall withstand an average of 5 dips in the case of the non-siliceous grade and 3 dips in the case of the siliceous grade.

(*d*) *Deformation.*—Deformation in the standard load test at 1350° C., under a load of 25 lb. per sq. in., shall not be over 6 per cent in the case of the siliceous grade.

NOTE.—The refractoriness of the non-siliceous grade is assured by the softening point, but for this requirement in the case of the siliceous grade, it is necessary to incorporate both the softening point and load test.

METHODS OF TESTING

Silica Content.

5. The determination of silica content shall be made in accordance with the analytical methods described in the Standard Methods of Ultimate Chemical Analysis of Refractory Materials, Including Chrome Ores and Chrome Brick (Serial Designation: C 18) of the American Society for Testing Materials.[1]

Softening Point.

6. (*a*) The softening point (fusion point) shall be determined in accordance with the Standard Method of Test for Softening Point of Fire-Clay Brick (Serial Designation: C 24) of the American Society for Testing Materials.[1]

(*b*) In the event that the material fails to pass the specified requirements by one cone or less, two additional softening point determinations shall be made as checks on the accuracy of the test and the final results judged on the basis of the three determinations. This procedure is necessary because of variations that have been found to exist in this test even where the standard methods are followed.

Spalling Test.

7. (*a*) The spalling test shall be conducted in accordance with the Tentative Method of Test for Resistance of Fire-Clay Brick to

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[1] 1927 Book of A.S.T.M. Standards, Part II.

Thermal Spalling Action (Serial Designation C 38 - 27 T) of the American Society for Testing Materials[1] (Note 1). The test shall be continued until each brick shall have lost 20 per cent by weight or until the total number of immersions necessary to give the required average has been obtained. Individual samples shall not be continued in the test after a loss of 20 per cent has been sustained. The brick shall be dried and weighed before and after testing and the loss computed as a percentage of the original dry weight.

Results. (*b*) The results in the spalling test for any one brand shall be reported as the average loss of 10 specimens selected at random. If desired, the test may be made on only 5 specimens, but when this is done an additional 5 specimens shall be tested in the event that the first 5 do not meet the requirements, and the results reported as the average of the entire 10.

Modulus of Rupture. 8. (*a*) The modulus of rupture shall be determined in accordance with the method of test for modulus of rupture of building brick, as described in Sections 8 to 12 of the Tentative Methods of Testing Brick (Serial Designation: C 67 - 27 T) of the American Society for Testing Materials.[2]

Results. (*b*) The results in the modulus of rupture test for any one brand shall be reported as the average of 10 specimens selected at random. If desired, the test may be made on only 5 specimens, but when this is done an additional 5 specimens shall be tested in the event that the first 5 do not meet the requirements, and the results reported as the average of the entire 10.

Load Test. 9. The load test shall be made in accordance with the Standard Method of Test for Refractory Materials Under Load at High Temperatures (Serial Designation: C 16) of the American Society for Testing Materials.[3]

EXPLANATORY NOTE

NOTE 1.—It will be noted that the present Tentative Method of Test for Resistance of Fire-Clay Brick to Thermal Spalling Action (C 38 - 27 T) of the American Society for Testing Materials is the one referred to in these specifications. It is recognized that there are other methods which have much to commend them; the 850° C. water dip spalling test developed at the Bureau of Standards; the air spalling test used by a large contracting company; and possibly others. It seems very probable however, in the light of past work and that now going on, that the ultimate spalling test may be different from any of these. Everything considered, it seems best to use Method C 38 for the present.

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[1] See p. 837.

[2] See p. 826.

[3] 1927 Book of A.S.T.M. Standards, Part II.

TENTATIVE METHODS OF TESTING BRICK[1]

Serial Designation: C 67 – 27 T

This is a **Tentative Standard,** published for the purpose of eliciting criticism and suggestions, and as such is subject to annual revision.

ISSUED, 1927.

Scope.

1. These methods cover the following tests for brick:
   - The compression test;
   - The flexure or cross-bending test;
   - The rattler test.

COMPRESSION TEST

APPARATUS

Apparatus.

2. Any form of standard testing machine may be used for the compression test together with a spherical bearing block large enough entirely to cover the specimen.

TEST SPECIMEN

Test Specimen.

3. The test specimen shall consist of a half-brick. Any method which will produce a specimen with approximately plane and parallel ends, without shattering the specimen, may be used.

NOTE.—This permits the use of a suitable half-brick from the flexure test.

Preparation of Test Specimen.

4. A half-brick to be used for the compression test shall be prepared as follows: The two surfaces intended to receive the load from the testing machine shall receive a thin coating of shellac and be allowed to dry thoroughly. One of the shellaced bearing surfaces shall then receive a thin coat of a neat mortar of calcined gypsum (plaster of Paris). This mortared face of the specimen shall then be pressed on plate glass or a machined metal plate, previously oiled or covered with waxed paper, and the bedding material allowed to harden. This procedure shall be repeated with the other shellaced surface. Care shall be taken that the opposite faces so coated with bedding material shall be parallel. Depressions of recessed or panelled bricks shall be filled with neat portland-cement mortar which shall stand at least 24 hours before testing.

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[1] Criticisms of these Tentative Methods are solicited and should be directed to Mr. J. W. McBurney, Secretary of Committee C-3 on Brick, U. S. Bureau of Standards, Washington, D. C.

5. Compression tests shall be made on at least five half-brick test specimens from different bricks. **Number of Tests.**

PROCEDURE

6. (*a*) The half-brick test specimen shall be tested, placed flat. **Procedure.**

(*b*) The bearing block shall be used on top of the test specimen in vertical testing machines. The center of the sphere of the bearing block shall be used in contact with the top bearing surface of the specimen, and in the vertical axis of the specimen. (Fig. 1.) The spherical bearing block shall be kept thoroughly lubricated to insure accurate adjustment, which should be made by hand under a small initial load.

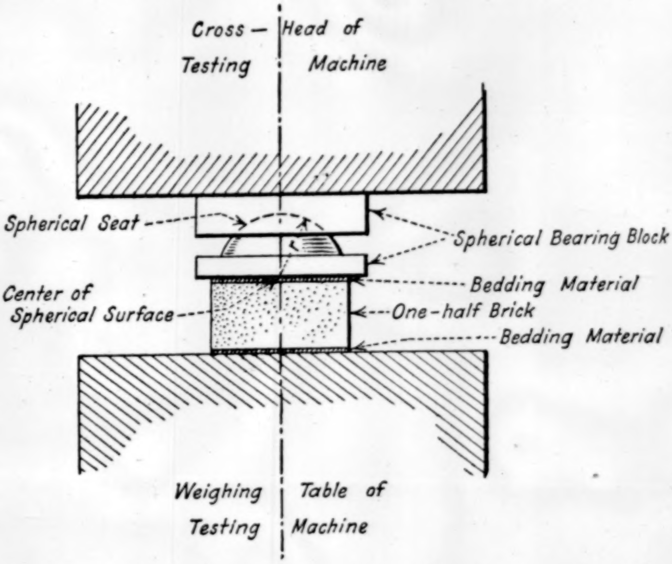

Cross - Head of
Testing Machine
Spherical Seat
Spherical Bearing Block
Bedding Material
Center of Spherical Surface
One-half Brick
Bedding Material
Weighing Table of
Testing Machine

FIG. 1.—Special Bearing Block for Use in Testing Brick.

(*c*) The speed of the moving head of the testing machine, during the application of the load, shall not be more than 0.05 in. per minute.

(*d*) During the test the beam of the testing machine shall be kept constantly in a floating position.

7. The compressive strength in pounds per square inch shall be reported as the total maximum load, W, in pounds, indicated by the testing machine, divided by the area, A, in square inches, of the minimum section of the specimen perpendicular to the line of application of the load. **Compressive Strength.**

The compressive strength in pounds per square inch shall be calculated from the formula:

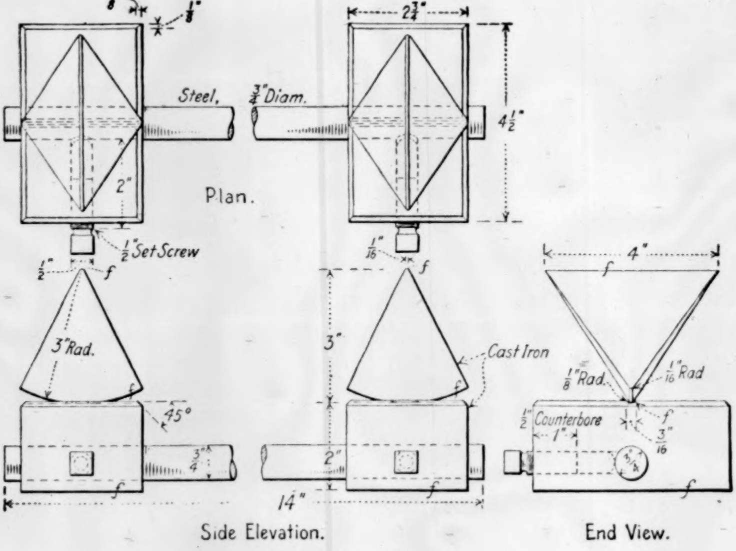
$$\text{Compressive strength} = \frac{W}{A}$$

FLEXURE TEST

APPARATUS

Apparatus. 8. (*a*) Any form of standard testing machine with knife edges as described in Paragraph (*b*) may be used for the flexure test.

NOTE.—Portable apparatus properly calibrated may be used.



1/8"
1/8"
2 3/4"
Steel.
3/4" Diam.
4 1/2"
2"
Plan.
1/2" Set Screw
1/2"
f
1/16"
f
4"
f
3" Rad.
3"
Cast Iron
1/8" Rad.
1/16" Rad
45°
1/2" Counterbore
1"
f
3/16"
3/4"
3/4"
2"
14"
f
f
f

Side Elevation.

End View.

FIG. 2.

(*b*) Knife edges shall be straight and have full contact with the specimen or bearing plate and they shall have a length at least equal to the width of the brick to be tested. Their bases shall be so curved or rounded as to permit free movement of the working edges, both longitudinally and transversely. The use of knife edges of the type shown in Fig. 2 is recommended, although other types may be used which will provide free movement and at the same time insure full and even bearing at all times during the test.

TEST SPECIMEN

Test Specimen. 9. The test specimen shall be a whole brick.

Number of Tests. 10. Flexure tests shall be made on at least five whole bricks.

PROCEDURE

11. (*a*) A test specimen brick shall be placed flat-wise on the knife edges with a span of 7 in. and the load applied at mid-span. **Procedure.**

(*b*) A steel bearing piece $\frac{1}{2}$ in. square and of a length equal to the full width of the specimen shall be placed between the upper knife edge and the specimen.

(*c*) The speed of travel of the head of the testing machine, during the application of the load, shall not be more than 0.05 in. per minute.

12. The modulus of rupture, R, in pounds per square inch shall be reported as calculated from the following formula: **Modulus of Rupture.**

$$R = \frac{3Wl}{2bd^2}$$

where W = the total load in pounds at which the brick failed;
l = the distance between the supports in inches;
b = the width of the brick in inches; and
d = the depth of the brick in inches.

RATTLER TEST

APPARATUS

13. The machine used in the rattler test shall be of good mechanical construction, self-contained, and shall conform to the following details of material and dimensions, and shall consist of barrel, frame and driving mechanism as described in Sections 14 to 18. In Fig. 3 (Plate I) is illustrated a rattler which will meet the requirements specified, and to which reference should be made. **Apparatus.**

14. The barrel of the machine shall consist of the heads, head-liners, staves, and stave-liners conforming to the following requirements: **Barrel.**

(*a*) *Heads.*—The heads may be cast in one piece with the trunnions which shall be $2\frac{7}{16}$ in. in diameter, and shall have a bearing 6 in. in length; or they may be cast with heavy hubs, which shall be bored out for $2\frac{7}{16}$ in. shafts and shall be key-seated for two keys, each $\frac{1}{2}$ by $\frac{3}{8}$ in. and spaced 90 deg. apart. The shaft shall be a snug fit and when keyed shall be entirely free from lost motion. The distance from the end of the shaft or trunnion to the inside face of the head shall be $15\frac{3}{8}$ in. in the head for the driving end of the rattler and $11\frac{3}{8}$ in. for the other head, and the distance from the face of the hubs to the inside face of the heads shall be $5\frac{1}{8}$ in.

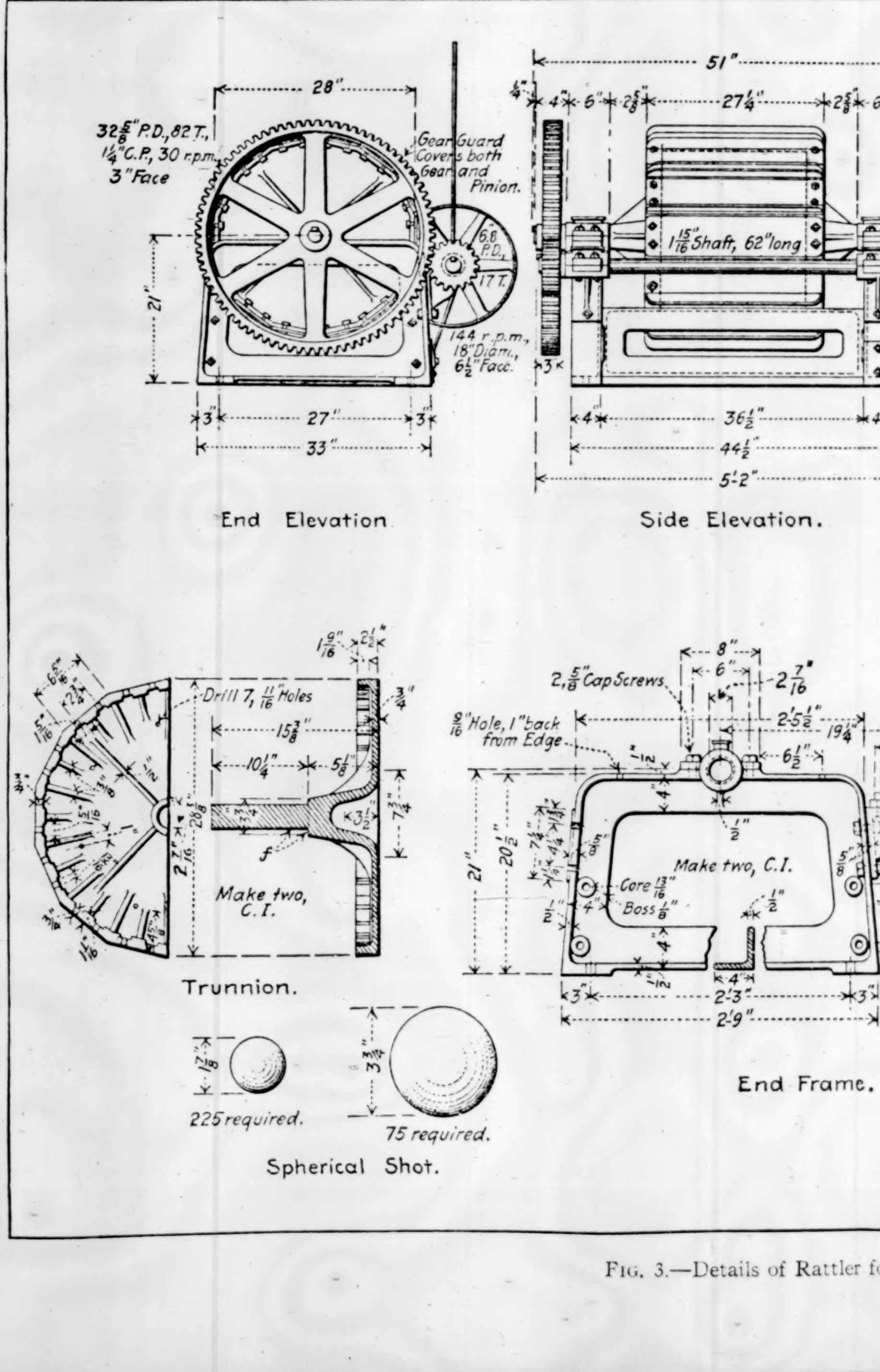
The heads shall not be less than $\frac{3}{4}$ nor more than $\frac{7}{8}$ in. in thickness. In outline, each head shall be a regular 14-sided polygon inscribed in a circle $28\frac{3}{8}$ in. in diameter. Each head shall be provided with flanges not less than $\frac{3}{4}$ in. in thickness and extending outward $2\frac{1}{2}$ in. from the inside face of the head to afford a means of fastening the staves. The surface of the flanges of the head shall be smooth and give a true and uniform bearing for the staves. To secure the desired true and uniform bearing, the surfaces of the flanges of the head shall be either ground or machined. The flanges shall be slotted on the outer edge, so as to provide for two $\frac{3}{4}$-in. bolts at each end of each stave, the slots to be $\frac{13}{16}$ in. in width and $2\frac{3}{4}$ in. center to center. Each slot shall be provided with a recess for the bolt head, which shall act to prevent the turning of the same. Between each two slots there shall be a brace $\frac{3}{8}$ in. in thickness extending down the outward side of the head not less than 2 in.

(*b*) *Headliners.*—There shall be for each head a cast-iron headliner, 1 in. in thickness and conforming to the outline of the head, but inscribed in a circle $28\frac{1}{8}$ in. in diameter. This headliner shall be fastened to the head by seven $\frac{5}{8}$-in. cap screws, through the head from the outside. Whenever these headliners become worn down $\frac{1}{2}$ in. below their initial surface level, at any point of their surface, they shall be replaced with new ones. The metal of these headliners shall be hard machinery iron and should contain not less than 1 per cent of combined carbon.

(*c*) *Staves.*—The staves shall be made of 6-in. medium-carbon steel structural channels $27\frac{1}{4}$ in. in length and weighing 15.5 lb. per lineal foot. The staves shall have two holes $\frac{13}{16}$ in. in diameter, drilled in each end, the center line of the holes being 1 in. from the end and $1\frac{3}{8}$ in. either way from the longitudinal center line. The spaces between the staves shall be as uniform as practicable, but shall not exceed $\frac{5}{16}$ in.

(*d*) *Staveliners.*—The interior or flat side of each stave shall be protected by a liner $\frac{3}{8}$ in. thick by $5\frac{1}{2}$ in. wide by $19\frac{3}{4}$ in. long. The liner shall consist of medium-carbon steel plate, and shall be riveted to the channel by three $\frac{1}{2}$-in. rivets, one of which shall be on the center line both ways and the other two on the longitudinal center line and spaced 7 in. from the center each way. The rivet holes shall be counter-sunk on the face of the liner and the rivets shall be driven hot and chipped off flush with the surface of the liners. These liners shall be inspected from time to time, and if found loose shall be at once re-riveted.

Preliminary Operation. 15. When a new rattler, in which a complete set of new staves is furnished, is first put into operation, it shall be charged with 400 lb. of shot of the same sizes, and in the same proportion as provided in

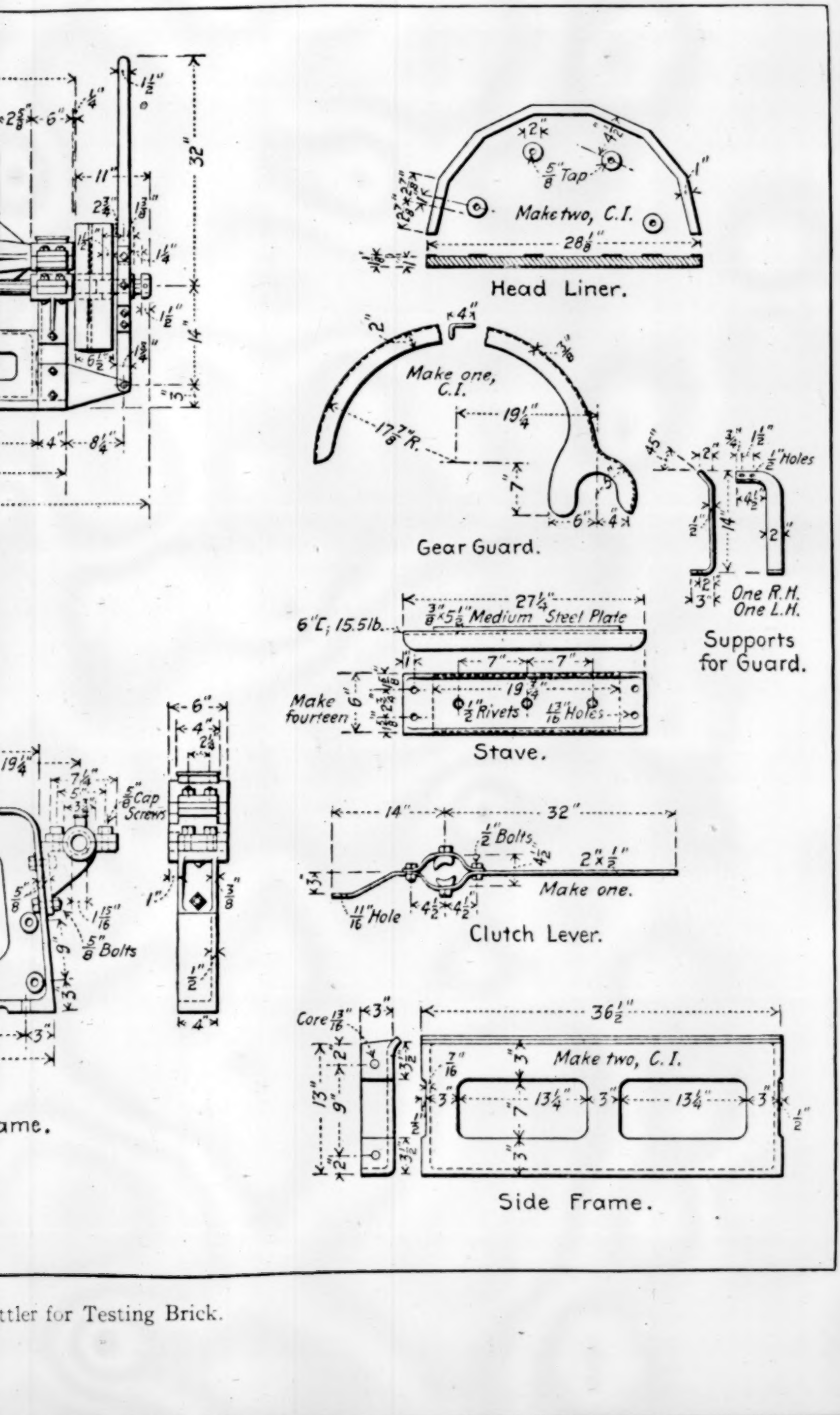


28"
32 5/8" P.D., 82 T.,
1 1/4" C.P., 30 r.p.m.
3" Face
Gear Guard Covers both Gear and Pinion.
6.8 P.D.,
17 T.
144 r.p.m.,
18" Diam.,
6 1/2" Face.
21"
3"
27"
3"
33"
End Elevation
51"
1/4"
4"
6"
2 5/8"
27 1/4"
2 5/8"
1 15/16" Shaft, 62" long
3"
4"
36 1/2"
44 1/2"
5'-2"
Side Elevation.
1 9/16"
2 1/2"
Drill 7, 11/16" Holes
3/4"
15 7/8"
10 1/4"
5 5/8"
7 3/4"
3 1/2"
3 3/4"
f
28 5/8"
2 7/16"
6 5/8"
2 3/4"
1 5/16"
Make two, C.I.
Trunnion.
2, 5/8" Cap Screws
8"
6"
2 7/16"
9/16" Hole, 1" back from Edge
2'-5 1/2"
19 1/4"
6 1/2"
1/2"
4"
21"
20 1/2"
7 1/4"
4 1/4"
Make two, C.I.
Core 13/16"
Boss 1/8"
1/2"
4"
2 1/2"
4"
3"
2'-3"
3"
2'-9"
End Frame.
1 7/8"
225 required.
3 3/4"
75 required.
Spherical Shot.

FIG. 3.—Details of Rattler f

PLATE VII.
PROC. AM. SOC. TESTING MATS.
VOL. 27, PART I.

TENTATIVE METHODS OF TESTING BRICK.



Head Liner.
Make two, C.I.
5/8" Tap
28 1/8"
Gear Guard.
Make one, C.I.
17 7/8" R.
19 1/4"
Supports for Guard.
One R.H.
One L.H.
1/2" Holes
Stave.
Make fourteen
6" [; 15.5 lb.
3/8" × 5 1/2" Medium Steel Plate
27 1/4"
19 3/4"
1/2" Rivets
13/16" Holes
Clutch Lever.
Make one.
1/2" Bolts
2" × 1/2"
11/16" Hole
14"
32"
Side Frame.
Make two, C.I.
36 1/2"
13 1/4"
Core 13/16"
5/8" Cap Screws
5/8" Bolts
ame.

ttler for Testing Brick.

Section 19, and shall then be run for 18,000 revolutions at the rate of speed specified in Section 22(*a*). The shot shall then be removed and a standard shot charge inserted after which the rattler may be charged with brick for a test.

Relining. 16. No stave shall be used for more than 70 consecutive tests without renewing its lining. Two of the 14 staves shall be removed and relined at a time in such a way that of each pair, one falls upon one side of the barrel and the other upon the opposite side, and also so that the staves changed shall be consecutive, but not contiguous: for example, 1 and 8, 3 and 10, 5 and 12, 7 and 14, 2 and 9, 4 and 11, 6 and 13, etc., to the end that the interior of the barrel at all times shall present the same relative conditions of repair. The changes in the staves should be made at the time when the shot charges are being corrected, and the record must show the number of charges run since the last pair of new lined staves was placed in position.

The staves when bolted to the heads shall form a barrel 20 in. in length, inside measurement, between headliners. The liners of the staves shall be so placed as to drop between the headliners. The staves shall be bolted tightly to the heads by four $\frac{3}{4}$-in. bolts and each bolt shall be provided with a locknut and shall be inspected at not less frequent intervals than every fifth test and all nuts kept tight. A record shall be made after each inspection showing in what condition the bolts were found.

Barrel Frame. 17. The barrel shall be mounted on a cast-iron frame of sufficient strength and rigidity to support it without undue vibration. It shall rest on a rigid foundation with or without the interposition of wooden plates, and shall be fastened thereto by bolts at not less than four points.

Driving Mechanism. 18. The barrel shall be driven by gearing whose ratio of driver to driven is not less than one to four. The counter shaft upon which the driving pinion is mounted shall not be less than $1\frac{15}{16}$ in. in diameter, with bearing not less than 6 in. in length. If a belt drive is used, the pulley shall be not less than 18 in. in diameter and $6\frac{1}{2}$ in. in face. A belt at least 6 in. in width, properly adjusted, to avoid unnecessary slipping, should be used.

Abrasive Charge. 19. The abrasive charge shall consist of cast-iron spheres of two sizes.

(*a*) *Large Spheres.*—When new, the larger spheres shall be 3.75 in. in diameter and shall weigh approximately 7.5 lb. (3.40 kg.) each. Ten spheres of this size shall be used. These shall be weighed separately after each ten tests, and if the weight of any large sphere falls to 7 lb. (3.175 kg.) it shall be discarded and a new one substituted;

provided, however, that all of the large spheres shall not be discarded and substituted by new ones at any single time, and that in so far as possible the large spheres shall compose a graduated series in various stage of wear.

(*b*) *Small Spheres.*—When new, the smaller spheres shall be 1.875 in. in diameter and shall weigh approximately 0.95 lb. (0.43 kg.) each. In general, the number of small spheres in a charge shall not fall below 245 nor exceed 260. The collective weight of the large and small spheres shall be as nearly 300 lb. as possible. No small sphere shall be retained in use after it has been worn down so that it will pass a circular hole 1.75 in. in diameter, drilled in an iron plate ¼ in. in thickness, or weigh less than 0.75 lb. (0.34 kg.).

Further, the small spheres shall be tested by passing them over the plate mentioned or by weighing, after every ten tests, and any which pass through or fall below the specified weight, shall be replaced by new spheres, provided, further, that all of the small spheres shall not be rejected and replaced by new ones at any one time, and that so far as possible the small spheres shall compose a graduated series in various stages of wear. At any time that any sphere is found to be broken or defective it shall at once be replaced.

Chemical Composition of Charge.

20. The cast-iron abrasive spheres shall conform to the following requirements as to chemical composition:

Combined carbon	Not under	2.50 per cent
Graphitic carbon	" over	0.25 " "
Silicon	" "	1.00 " "
Manganese	" "	0.50 " "
Phosphorus	" "	0.25 " "
Sulfur	" "	0.08 " "

For each new batch of spheres used, the chemical analysis shall be furnished by the maker or be obtained by the user, before introducing the spheres into the charge, and unless the analysis conforms to the requirements specified, the batch of spheres shall be rejected.

Scales.

21. The scales used shall be placed on a solid level foundation and shall be sufficiently sensitive to determine the initial weight of 10 bricks to the nearest 0.1 lb. The scale shall be tested by a standard test weight at intervals of not more than every ten tests.

TEST SPECIMEN

Test Specimen.

22. The number of brick per test shall be ten whole bricks for all weights of brick, and the brick shall be weighed to the nearest 0.1 lb. No brick should be selected as part of a regular test that would be rejected by any other requirements of the specifications under which the purchase is made.

PROCEDURE

Procedure.

23. (*a*) The sample, together with the abrasive charge shall be placed in the rattler and the rattler closed. The rattler shall be rotated at a uniform rate of not less than 29.5 nor more than 30.5 revolutions per minute, and 1800 revolutions shall constitute the test. A counting machine shall be attached to the rattler for counting the revolutions. A margin not to exceed ten revolutions will be allowed for starting and stopping. Only one start and stop per test is in general acceptable. If, from accidental causes, the rattler is stopped and started more than once during a test, and the percentage loss exceeds the maximum permissible under the specifications, the test shall be disqualified and another made.

(*b*) Any test, at the expiration of which a stave-liner is found detached from the stave or seriously out of position, shall be rejected.

Percentage Loss of Weight.

24. The loss shall be calculated as a percentage of the initial weight of the brick composing the charge, by weighing the brick remaining in the rattler at the end of the test, deducting this weight from the initial weight of the brick, dividing this difference by the original weight of the brick and multiplying by 100.

$$\text{Percentage of Loss} = \frac{\text{Original Weight} - \text{Weight after Testing}}{\text{Original Weight}} \times 100$$

In weighing the rattled brick, any piece weighing less than 1 lb. shall be rejected.

NOTE.—The percentage of loss to be taken as the standard remains within the province of the contracting parties. For their information, the average percentage of loss after correction as provided in Section 25 should not exceed 22 per cent for heavy traffic and 24 per cent for light traffic.

Corrected Percentage of Loss.

25. The percentages of loss, as calculated in accordance with Section 24, shall be corrected by subtracting from it the differential obtained from the following table, which corresponds to the initial weight of the ten brick composing the test charge. The corrected result shall be reported as the corrected percentage of loss.

WEIGHT OF 10 BRICK BEFORE TEST, LB.	CORRECTION DIFFERENTIAL, PER CENT
95 or over	0
90 to 94 inclusive	1.0
85 to 89 "	1.5
80 to 84 "	2.5
75 to 79 "	3.0
70 to 74 "	3.5
65 to 69 "	4.0
60 to 64 "	5.0
59 or under	6.0

In all cases where the initial weight of 10 brick in pounds and tenths of a pound lies between the upper limit of one grade and the lower limit of the next heavier grade, the brick shall be classified in the heavier grade when the fractional part of the weight is 0.5 lb. or more.

RECORD

Rattler Record. 26. A complete and continuous record shall be kept of the operation of all rattlers working under these tentative methods of testing. This record shall contain the following data concerning each test made:

1. The name of the person, firm or corporation furnishing each sample tested.
2. The name of the maker of the brick represented in each sample tested.
3. The name of the street or contract, which the sample represented.
4. The brands or marks upon the bricks by which they were identified.
5. The number of bricks furnished.
6. The date on which they were received for test.
7. The date on which they were tested.
8. The drying treatment given before testing, if any.
9. The length, width and thickness of the bricks.
10. The collective weight of the ten large spherical shot used in making the test at the time of their last standardization.
11. The number and collective weight of the small spherical shot used in making the test at the time of their last standardization.
12. The total weight of the shot charge, after its last standardization.
13. Certificate of the operator that he examined the condition of the machine as to staves, liners, and any other parts affecting the barrel, and found them to conform to the requirements at the beginning of the test.
14. Certificate of the operator of the number of charges tested since the last standardization of shot charge and last renewals of stave liners.
15. The time of the beginning and ending of each test, and the number of revolutions made by the barrel during the test, as shown by the counting machine.
16. Certificate of the operator as to number of stops and starts made in each test.
17. The initial collective weight of the ten brick composing the charge and their collective weight after rattling.
18. The loss calculated as a percentage of the initial weight and the calculation itself, the correction factor, and the corrected percentage of loss.
19. The number of broken bricks and remarks upon the portions which were included in the final weighing.
20. General remarks upon the test and any irregularities occuring in its execution.
21. The certificate of the operator that the test was made in accordance with the requirements of the American Society for Testing Materials and that the record is a true record.

22. The signature of the operator or person responsible for the test.
23. The location of the laboratory where the test was made and name of the owner.
24. The serial number of the test.

In the event of more than one copy of the record of any test being required, they may be furnished on separate sheets and marked duplicate, but the original record shall always be preserved intact and complete.

NOTE.—For the convenience of those making use of the test, the accompanying blank form, which provides space for the necessary data, is furnished and its use is recommended.

REPORT OF STANDARD RATTLER TEST OF PAVING BRICK

IDENTIFICATION DATA

Name of firm furnishing sample..........

Name of firm manufacturing sample..........

Street or job which sample represents..........

Brands or marks on the brick..........

Quantity furnished.......... Drying treatment..........

Date received.......... Date tested..........

Length.......... Width.......... Thickness..........

STANDARDIZATION DATA

WEIGHT OF CHARGE (After Standardization)	CONDITION OF LOCKNUTS ON STAVES	CONDITION OF SCALES	NUMBER AND POSITION OF FRESH STAVE LINERS	REPAIRS (Note any repairs affecting the condition of the barrel.)
10 Large spheres..........				
Small spheres..........				
Total..........				

Number of charges tested since last inspection..........

RUNNING DATA

TIME READINGS				REVOLUTION COUNTER READINGS	RUNNING NOTES, STOPS, ETC.
	HOURS	MINUTES	SECONDS		
Beginning of test..........					
Final reading..........					

WEIGHTS AND CALCULATIONS

	PERCENTAGE LOSS (NOTE.—The calculation must appear.)
Initial weight of ten brick..........	
Final weight of ten brick..........	
Loss in weight..........	
Percentage loss..........	
Correction differential..........	
Corrected percentage of loss..........	

Number of broken brick and remarks on same..........

I certify that the foregoing test was made in accordance with the methods of testing of the American Society for Testing Materials and is a true record.

Signature of Tester..........

Date..........

Location of Laboratory..........

Owner..........

Serial No..........

TENTATIVE METHOD OF TEST

FOR

RESISTANCE OF FIRE-CLAY BRICK TO THERMAL SPALLING ACTION[1]

Serial Designation: C 38 – 27 T

This is a **Tentative Standard,** published for the purpose of eliciting criticism and suggestions, and as such is subject to annual revision.

ISSUED, 1921; REVISED, 1926, 1927.

Object.

1. The object of this test is to determine the resistance of high-duty fire-clay brick to spalling action, by subjecting them to repeated rapid temperature changes.

Preparation of Samples.

2. (*a*) The sample shall consist of at least five standard 9-in. brick or of five shapes, which may be cut to standard size with a grinding wheel.

(*b*) Test specimens of shapes such as boiler arch brick shall be cut to the standard 9-in. size. For this purpose a "cut-off" wheel is recommended.

Procedure.

3. (*a*) The specimens shall be weighed and placed in a door of a furnace operated at 1350° C. (2462° F.), care being taken to prevent the direct heating of more than the $2\frac{1}{2}$ by $4\frac{1}{2}$-in. end. After one hour the specimen shall be withdrawn from the furnace and stood on end in a tank of flowing cold water from 10 to 21° C. (50 to 70° F.) so that the hot end of the brick will be immersed to a depth of 2 in. After three minutes the sample shall be withdrawn from the water, allowed to steam five minutes and then returned to the furnace. The door of the furnace shall be closed while the bricks are out to prevent the lowering of the temperature. The alternate heating and cooling shall be continued in hourly cycles until a loss of 20 per cent by weight has occured in each brick.

(*b*) When pieces begin to fall off, the sample is laid on a 4.5 by 9.0-in. asbestos board, divided into one hundred equal squares, and the approximate percentage of loss estimated after each removal from the water. After the completion of the test, the brick is again weighed and the percentage of loss determined.

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[1] Criticisms of this Tentative Method are solicited and should be directed to Mr. L. J. Trostel, Secretary of Committee C-8 on Refractories, General Refractories Co. Laboratories, P. O. Box 935, Baltimore, Md.

Reporting Results.

4. The report shall show for each brick the number of dips before loss started, the percentage of loss after each cooling and the total number of dips until a loss of 20 per cent by weight has occurred.

TENTATIVE DEFINITIONS OF TERMS RELATING TO REFRACTORIES[1]

Serial Designation: C 71 - 27 T

This is a **Tentative Standard,** published for the purpose of eliciting criticism and suggestions, and as such is subject to annual revision.

Issued, 1927.

Plastic or Bond Fire Clay.—A fire clay of sufficient natural plasticity to bond non-plastic materials.

Flint Fire Clay.—A hard or flint-like fire clay occurring as an unstratified massive rock, practically devoid of natural plasticity and breaking with a concoidal fracture.

Diaspore Clay.—A rock consisting essentially of diaspore bonded by fire clay.

Nodular Fire Clay.—A rock containing aluminous and/or ferruginous nodules bonded by fire clay.

Note.—In some districts such clays are called "burley" or "burley flint" clay.

Spalling.—Breaking or cracking of refractories to such an extent that fragments are separated, presenting newly exposed surfaces of the residual mass.

Note.—The causes of spalling may be classified under three main headings: namely, thermal, mechanical and structural, as follows:

Thermal:

(*a*) *Factors Related to Service.*—Rapidity and range of thermal fluctuation; contamination by slags and fluxes; tightness of joints; previous vitrification.

(*b*) *Factors Related to Refractories.*—Degree and uniformity of reversible thermal expansion; heat transfer; elasticity; plastic flow.

Mechanical:

(*a*) *Factors Related to Service.*—Rapid heating of wet brick; abuse in removing clinker and slag; unequal and excessive stresses; pinching; no provision for expansion; thin joints.

(*b*) *Factors Related to Refractories.*—Mechanical strength; toughness; accuracy of shape.

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[1] Criticisms of these Tentative Definitions are solicited and should be directed to Mr. L. J. Trostel, Secretary of Committee C-8 on Refractories, General Refractories Co. Laboratories, P. O. Box 935, Baltimore, Md.

Structural:

(*a*) *Factors Related to Service.*—Slags and fluxes; character of the material in joints; insulation of refractories.

(*b*) *Factors Related to Refractories.*—Vitrification; shrinkage; nature of bond; structure; degree of burning.

Pyrometric Cone Equipment (*P.C.E.*).—An index to the degree of fusion resulting in a cone of the material bending until the tip touches the plaque as a result of a definite heat treatment, in accordance with the Standard Method of Test for Softening Point of Fire-Clay Brick (Serial Designation: C 24) of the American Society for Testing Materials.[1]

NOTE.—The terms "fusion point," "softening point" "deformation point" and "melting point" have heretofore been loosely used for "pyrometric cone equivalent."

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[1] 1927 Book of A.S.T.M. Standards, Part II.

TENTATIVE SPECIFICATIONS AND TESTS
FOR
HOLLOW BURNED-CLAY FIREPROOFING, PARTITION AND FURRING TILE[1]

Serial Designation: C 56 - 27 T

This is a **Tentative Standard,** published for the purpose of eliciting criticism and suggestions, and as such is subject to annual revision.

ISSUED, 1924; REVISED, 1926, 1927.

SPECIFICATIONS

Application.

1. These specifications apply to hollow fireproofing, partition and furring tile made from surface clay, shale, fire clay or admixtures thereof.

CLASSIFICATION

Classification.

2. (*a*) According to the results of physical tests, tile shall be classified as Hard, Medium, and Soft on the basis of the following strength and absorption requirements, both of which must be met for a given class:[2]

Class	Absorption, per cent		Compressive Strength Based on Net Area, lb. per sq. in.			
			End Construction		Side Construction	
	Mean of 5 Tests	Individual Maximum	Mean of 5 Tests	Individual Minimum	Mean of 5 Tests	Individual Minimum
Hard	12 or less	15	4600 or more	3000	2400 or more	1700
Medium	16 or less	19	3200 or more	2250	1600 or more	1100
Soft	25 or less	28	2000 or more	1400	1200 or more	850

(*b*) Where end-construction tiles are used on the side they shall meet the requirements of that construction, and *vice versa*.

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[1] Criticisms of these Tentative Specifications and Tests are solicited and should be directed to Mr. H. D. Foster, Secretary of Committee C-10 on Hollow Masonry Building Units, Engineering Experiment Station, Ohio State University, Columbus, O.

[2] As different types of clay are used in the manufacture of tile, color cannot be taken as indicative of classification.

WEIGHTS

Weights. 3. (*a*) The tile shall have the following dry weights determined as hereinafter specified:

STANDARD PARTITION TILE

DIMENSIONS, IN.	MINIMUM NUMBER OF CELLS	STANDARD WEIGHT, LB.
3 by 12 by 12	3	15
4 by 12 by 12	3	16
6 by 12 by 12	3	22
6 by 12 by 12	4	25
8 by 12 by 12	4	30
10 by 12 by 12	4	35
12 by 12 by 12	4	40

(*b*) A tolerance of 5 per cent will be allowed on the above standard weights.

DIMENSIONS

Dimensions. 4. No dimension shall vary more than 3 per cent from the standard dimensions for any form of tile.

FIRE RESISTANCE

Fire Resistance. 5. In cases where the fire resistance is an essential property the purchaser shall specify the degree of fire resistance (fire-resistance period) required, and the manufacturer shall supply such available information on the fire test performance of the given or closely similar product as will aid the purchaser in deciding whether the requirements are met. Further tests in accordance with the Tentative Specifications for Fire Tests of Building Construction and Materials (Serial Designation: C 19 – 26 T) of the American Society for Testing Materials[1] may be conducted by the purchaser.

WORKMANSHIP AND FINISH

Workmanship. 6. All tile shall be well burned, reasonably free from laminations and from such cracks, blisters, surface roughness and other defects as would evidently interfere with the proper setting of the tile or impair the permanence of the construction.

Scoring. 7. The exterior surface of all tile intended for plaster shall be scored in such a manner as to give good adhesion.

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 26, Part I, p. 761 (1926); also 1927 Book of A.S.T.M. Tentative Standards, p. 291.

MARKING

Marking. 8. All tile shall bear the initials, name or trademark of the manufacturer. Hollow tile intended for use in partitions shall also be marked "PARTITION." These marks shall be indented on the exterior of the tile and shall be plainly legible.

INSPECTION AND REJECTION

Inspection. 9. Proper facilities shall be provided the purchaser for sampling and inspection either at the factory or at the site of the work, as may be specified in the contract. At least 10 days from the time of sampling shall be allowed for the completion of the test. The inspection shall be based on the requirements specified above. All tests shall be made in accordance with the methods hereinafter prescribed.

Rejection. 10. (*a*) Individual tile shall be rejected for failure to meet the weight, size, or workmanship and finish requirements. In case of failure to meet the absorption and strength requirements for the class specified, the seller may sort the shipment and new samples shall be selected by the purchaser from the retained lot and tested at the expense of the seller. In case the second set of samples fails to meet the test requirements, the entire lot shall be rejected.

Acceptance. (*b*) By agreement, acceptance may be based on dry weight of the units, percentage of absorption, fire resistance and the workmanship and finish.

Expense of Tests. 11. Except as specified in Section 10, and unless otherwise agreed, the expense of inspection and testing shall be borne by the purchaser.

TESTS

SAMPLING

Selection of Samples for Test. 12. Samples of tile for testing shall be selected by the purchaser or by a competent representative authorized by him to do this work. In all cases the samples shall be representative of the whole lot of tile from which they are selected. Full-size tile shall be taken in all cases.

Number of Samples. 13. For the strength, absorption, and weight determinations, five individual tile shall be selected from each kiln or from each 100-ton lot. In no case shall less than five tile be taken. For the fire test the size of the test panel will govern the number of tile required.

Time and Place of Selecting Samples. 14. Samples for the strength and absorption tests shall be selected at the factory or at the site of the work, as specified in the contract. If the fire tests are to be made, it shall be so specified at the time of placing the order, samples being selected at the factory at least 45 days in advance of the time of filling the order.

Marking Samples. 15. All tile selected for test shall be plainly and permanently marked for reference by the testing operator.

IX. WEIGHT DETERMINATIONS

Weight Determinations. 16. The five tile, if not in kiln-dry condition, shall be dried to constant weight at a temperature of not less than 100° C. (212° F.) and be weighed separately. The scale shall be sensitive to within 0.5 per cent of the weight of the smallest unit.

X. STRENGTH TESTS

Samples. 17. Five full-size dry tile shall be used.

Speed of Testing Machine. 18. The speed of the moving head of the testing machine shall not be more than 0.05 in. per minute.

Bearing Block. 19. A spherical bearing block of proper design shall be placed on top of the test sample.

Capping. 20. (*a*) Bearing surfaces of the test samples and portions adjoining them which are liable to absorb water from the plastic capping shall be coated with shellac and allowed to dry. A quantity of plastic mortar made of a mixture of three parts (by volume) of portland cement and one part of unretarded gypsum (plaster of Paris) mixed with sufficient water to spread evenly shall be placed on a plain surface which has been coated with oil, and allowed to harden sufficiently to bear the weight of the tile. The surface to be capped shall be placed on this mortar, and while holding the specimen so that its axis is at right angles to the capping surface it shall be given a single firm pressure.

(*b*) The average thickness of the cap after the extruded plaster has been removed and the edges trued shall not be more than $\frac{1}{8}$ in. Patching of caps after setting shall not be permitted. Imperfect caps shall be removed and replaced with new ones.

(*c*) Where time is not available for aging the cement-gypsum cap, a cap of neat gypsum may be used, although the resulting tile strength will generally be lower than with the cement-gypsum cap. If the tile so capped fail to pass specification requirements on the score of strength, they shall be retested with portland-cement-gypsum caps aged not less than three days.

Time of Testing. 21. When the cement-gypsum cap is used it shall age at least three days before the tile is tested. Where the neat gypsum cap is used the tile may be tested as soon as the plaster has been well set, but not sooner than one hour after the sample has been capped.

Position of Tile. 22. All tile shall be tested in a position such that the load is applied in the same direction as in service.

XI. ABSORPTION TESTS

Selection of Test Samples. 23. The samples shall consist of five tile or three representative pieces from each of these five tile. If small pieces are used two shall be taken from the shell and one from an interior web, the weight of each piece to be not less than 227 g. ($\frac{1}{2}$ lb.). The samples shall have had their rough edges or loose particles ground off and be free from cracks from the failure of the tile in compression, where taken from tile which have been subjected to strength tests.

Marking Test Samples. 24. Each piece shall be marked so that it may be identified at any time with the tile from which it was taken. Markings which do not cover more than 5 per cent of the total superficial area of the piece shall be used.

Drying the Test Samples. 25. Preparatory to the absorption tests all samples shall be dried to constant weight in a drier or oven at a temperature of not less than 100° C. (212° F.).

Accuracy of Weighings. 26. The balance used shall be sensitive to within 0.2 per cent of the weight of the smallest unit or piece tested.

Saturation of Samples. 27. After obtaining the dry weight of the samples they shall be immersed in soft, distilled or rain water, raised to the boiling point and boiled continuously for one hour, and then allowed to cool in water to room temperature.

Obtaining Saturated Weights. 28. After saturation, the sample shall be removed from the water and allowed to drain for not more than one minute. The superficial water shall be removed with a damp cloth, after which they shall be weighed immediately.

Calculating and Reporting Results. 29. The test results shall be calculated as percentages of the initial dry weight, carried to the nearest first decimal place. The results shall be reported separately for each tile, with the average for the five tile.

TENTATIVE SPECIFICATIONS
FOR
BOILED LINSEED OIL[1]

Serial Designation: D 260 - 27 T

This is a **Tentative Standard,** published for the purpose of eliciting criticism and suggestions, and as such is subject to annual revision.

ISSUED, 1927.

PROPERTIES AND TESTS

Properties. 1. Boiled linseed oil shall be pure linseed oil that has been treated by heating and incorporating compounds of lead, and at the option of the manufacturer suitable compounds of other drying metals, so as to produce a product that will dry rapidly. It shall be clear, free from sediment, and shall conform to the following requirements, when tested in accordance with the methods described in Sections 2 to 12 inclusive:

	MAXIMUM	MINIMUM
Time of drying on glass, hours	18.0	....
Specific Gravity, 15.5/15.5° C	0.945	0.931[a]
Acid number	7.5	....
Saponification Number	195.0	189.0
Unsaponifiable Matter, per cent	1.50	....
Iodine Number (Wijs)	....	170.0
Loss on Heating at 105 to 110° C., per cent	0.2	....
Ash, per cent	0.50	....
Lead, per cent	....	0.05

[a] When a high viscosity type of boiled linseed oil is required, the specific gravity shall not be less than 0.937.

METHODS OF TESTING

Methods of Testing. 2. *General.*—All tests shall be made on oil that has been thoroughly agitated before the removal of a sample for analysis.

Time of Drying on Glass. 3. In determining the time of drying on glass, flow the sample over a perfectly clean glass plate. Place the plate in a vertical position in air that is at 30° C. ± 2° C. and of a humidity of 32-per-cent ±

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[1] Criticisms of these Tentative Specifications are solicited and should be directed to Mr. R. L. Hallett, Secretary of Committee D-1 on Preservative Coatings for Structural Materials, 105 York St., Brooklyn, N. Y.

4 per cent saturation. After about two hours, test the film at intervals with the finger at points not less than 2.5 cm. from the edges. The film shall be considered dry when it no longer adheres to the finger and does not rub up appreciably when the finger is lightly rubbed across the surface.

Specific Gravity.

4. In determining specific gravity, use a pyknometer, accurately standardized and having a capacity of at least 25 cc., or any other equally accurate method, making the test at 15.5° C. water being 1.000 at 15.5° C.

Acid Number.

5. In determining acid number, weigh from 5 to 10 g. of the sample. Transfer to a 300-cc. Erlenmeyer flask. Add 50 cc. of a mixture of equal parts by volume of 95-per-cent ethyl alcohol and c.p. reagent benzol. (This mixture should be previously titrated to a very faint pink with dilute alkali solution, using phenolphthalein as an indicator.) Add phenolphthalein indicator and titrate at once to a faint permanent pink color with 0.2 *N* sodium hydroxide solution. Calculate the acid number (milligrams KOH required for 1 g. of the oil).

Saponification Number.

6. In determining saponification number, weigh about 2 g. of the sample in a 300-cc. Erlenmeyer flask. Add 25 cc. of alcoholic sodium hydroxide or potassium hydroxide solution. Put a condenser loop inside the neck of the flask and heat on the steam bath for one hour. Cool, add phenolphthalein as indicator, and titrate with 0.5 *N* H_2SO_4. Run two blanks with the alcoholic sodium hydroxide solution. These should check within 0.1 cc. of 0.5 *N* H_2SO_4. From the difference between the number of cubic centimeters of 0.5 *N* H_2SO_4 required for the blank and for the determination, calculate the saponification number (milligrams KOH required for 1 g. of the oil).

Unsaponifiable Matter.

7. In determining unsaponifiable matter, weigh 8 to 10 g. of the sample. Transfer to a 250-cc. long-neck flask. Add 5 cc. of a strong solution of sodium hydroxide (equal weights of NaOH and H_2O) and 50 cc. of 95-per-cent ethyl alcohol. Put a condenser loop inside the neck of the flask and boil for two hours. Occasionally agitate the flask to break up the liquid, but do not project the liquid onto the sides of the flask. At the end of two hours, remove the condenser and allow the liquid to boil down to about 25 cc.

Transfer to a 500-cc. glass-stoppered separatory funnel, rinsing with water. Dilute with water to 250 cc., add 100 cc. of redistilled ether. Stopper and shake for one minute. Let stand until the two layers separate sharp and clear. Draw all but one or two drops of the aqueous layer into a second 500-cc. separatory funnel and repeat the process using 60 cc. of ether. After thorough separation, draw off the aqueous solution into a 400-cc. beaker, then the ether solution into the first separatory funnel, rinsing down with a little water. Return the aqueous solution to the second separatory funnel and shake out again with 60 cc. of ether in a similar manner, finally drawing the aqueous solution into the beaker and rinsing the ether into the first separatory funnel.

Shake the combined ether solution with the combined water rinsings and let the layers separate sharp and clear. Draw off the water and add it to the main aqueous solution. Shake the ether solution with two portions of water (about 25 cc. each). Add these to the main water solution.

Swirl the separatory funnel so as to bring the last drops of water down to the stop-cock and draw off until the ether solution just fills the bore of the stop-cock. Wipe out the stem of the separatory funnel with a bit of cotton on a wire. Draw the ether solution (portion-wise if necessary) into a 250-cc. flask and distill off. While still hot drain the flask into a small weighed beaker, rinsing with a little ether. Evaporate this ether, cool the beaker and weigh. (The unsaponifiable oil from adulterated drying oils may be volatile and as a consequence may evaporate on long heating. Therefore, heat the beaker on a warm plate, occasionally blowing out with a current of dry air. Discontinue heating as soon as the odor of ether is gone.)

Iodine Number.

8. In determining iodine number, place a small quantity of the sample in a small weighing burette or beaker. Weigh accurately. Transfer by dropping from 0.09 to 0.15 g. of oil to a 500-cc. bottle, having a well-ground glass stopper, or an Erlenmeyer flask, having a specially flanged neck for the iodine tests. Reweigh the burette or beaker and determine the amount of sample used. Add 10 cc. of chloroform. Whirl the bottle to dissolve the sample. Add 10 cc. of chloroform to each of two empty bottles like that used for the sample. Add to each bottle 25 cc. of the Wijs solution and let stand with occasional shaking for 1 hour in a dark place at a temperature of from 21 to 23° C. Add 10 cc. of the 15-per-cent potassium iodide solution and 100 cc. of water. Titrate with 0.1 *N* sodium thiosulfate, using starch as an indicator. The titrations on the two blank tests should agree within 0.1 cc. From the difference between the average of the blank titrations and the titration on the sample and the iodine value of the thiosulfate solution calculate the iodine number of the sample tested. (Iodine number is given in centigrams of iodine to 1 g. of the oil.)

Preparation of Wijs Iodine Monochloride Solution.—Dissolve iodine in glacial acetic acid that has a melting point of 14.7 to 15° C.

and is free from reducing impurities in the proportion so that 13 g. of iodine will be present in 1000 cc. of solution. The preparation of the iodine monochloride solution presents no great difficulty, but it shall be done with care and accuracy in order to obtain satisfactory results. There shall be in the solution no sensible excess either of iodine or more particularly of chlorine over that required to form the monochloride. This condition is most satisfactorily attained by dissolving in the whole of the acetic acid to be used the requisite quantity of iodine, using a gentle heat to assist the solution, if it is found necessary. Set aside a small portion of this solution while pure, and pass dry chlorine into the remainder until the halogen content of the solution is doubled. Ordinarily, it will be found that by passing the chlorine into the main part of the solution until the characteristic color of free iodine has just been discharged, there will be a slight excess of chlorine, which is corrected by the addition of the requisite amount of the unchlorinated portion until all free chlorine has been destroyed. A slight excess of iodine does little or no harm, but excess of chlorine must be avoided.

Loss on Heating at 105 to 110° C.

9. In determining the loss on heating, place 10 g. of the sample in an accurately weighed 50-cc. Erlenmeyer flask and weigh. Heat in an oven at a temperature between 105 and 110° C. for 30 minutes, then cool and weigh. Calculate the percentage loss. This determination shall be made in a current of carbon dioxide gas.

Ash.

10. In determining ash, weigh a porcelain crucible or dish. Add from 10 to 25 cc. of the sample, carefully weighing the amount added. Place on a stone slab on the floor of a hood. Ignite by playing the flame of a burner on the surface of the oil and allow to burn quietly until most of the oil is burned off; then transfer to a muffle or over a flame and continue heating at a low temperature (not over a dull red) until all carbonaceous matter is consumed. Cool, weigh, and compute the percentage of ash.

Leads.

11. In determining lead, dissolve the ash in dilute nitric acid to which a little hydrogen peroxide has been added and determine lead by the sulfate or any other equally accurate method.

Appearance.

12. Transfer a portion of the sample to a clear glass tube and note appearance.

TENTATIVE SPECIFICATIONS

FOR

PRUSSIAN BLUE[1]

Serial Designation: D 261 - 27 T

This is a **Tentative Standard,** published for the purpose of eliciting criticism and suggestions, and as such is subject to annual revision.

ISSUED, 1927

Scope.

1. These specifications cover the pigment commonly known as Prussian blue, Chinese blue, or iron blue. It may be purchased in the dry form, or ground in oil or in japan to form a paste.

MANUFACTURE

Process.

2. (*a*) *Dry Pigment.*—The dry pigment shall be the blue product formed by the reaction of solutions of iron salts with ferro or ferricyanide solution. It shall not be admixed with any other substance.

(*b*) *Paste in Oil.*—The paste in oil shall be made by thoroughly grinding the specified pigment in raw or refined linseed oil.

(*c*) *Paste in Japan.*—The paste in japan shall be made by thoroughly grinding the specified pigment in high-grade grinding japan.

PROPERTIES AND TESTS

Composition and Properties.

3. (*a*) The mass color and character of the tint formed by mixture with a white pigment shall be the same as, and the strength not less than, that of a sample mutually agreed upon by the buyer and seller.

(*b*) *Dry Pigment.*—The dry pigment shall conform to the following requirements:

Total matter soluble in water, maximum, per cent	0.5
Coarse particles (total residue retained on a No. 325 screen)[2], maximum, per cent	1.0

(*c*) *Paste in Oil.*—The paste as received shall not be caked in the container and shall break up readily in oil to form a smooth paint of brushing consistency. It shall mix readily in all proportions, without curdling, with linseed oil, turpentine or volatile mineral spirits, or any mixture of these substances. The paste shall conform to the following requirements:

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[1] Criticisms of these Tentative Specifications are solicited and should be directed to Mr. R. L. Hallett, Secretary of Committee D-1 on Preservative Coatings for Structural Materials, 105 York St., Brooklyn, N. Y.

[2] For determining coarse particles, screens 3 in. in diameter are recommended, conforming to the requirements of the Standard Specifications for Sieves for Testing Purposes (Serial Designation: E 11) of the American Society for Testing Materials, 1927 Book of A.S.T.M. Standards, Part II.

	Maximum	Minimum
Pigment, per cent	....	48.0
Linseed oil, per cent	52.0	....
Moisture and other volatile matter, per cent	0.7	....
Coarse particles and skins (total residue retained on a No. 325 screen[1]), per cent	1.5	....

(*d*) *Paste in Japan.*—The paste as received shall not be caked in the container and shall break up readily in turpentine to form a smooth paint of brushing consistency, that will dry within one hour to a hard flat coat that can be varnished within five hours of the time of application, without streaking or bleeding. The paste shall conform to the following requirements:

	Maximum	Minimum
Pigment, per cent	....	48.0
Vehicle (japan), per cent	52.0	....
Coarse particles and skins (total residue retained on a No. 325 screen[1]), per cent	1.5	....
Non-volatile matter in the vehicle, per cent of the vehicle	....	40.0

Note.—The physical properties and tests of Prussian blue, particularly the tinting strength, are considered a better measure of value than the percentages of chemical constituents.

4. One sample shall be taken at random from each lot of 1000 packages or fraction thereof. If the packages are of such size that 1000 amount to more than a carload, one sample shall be taken at random from each carload. **Number of Tests.**

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[1] For determining coarse particles, screens 3 in. in diameter are recommended, conforming to the requirements of the Standard Specifications for Sieves for Testing Purposes (Serial Designation: E 11) of the American Society for Testing Materials, 1927 Book of A.S.T.M. Standards, Part II.

TENTATIVE SPECIFICATIONS
FOR
ULTRAMARINE BLUE[1]

Serial Designation: D 262 - 27 T

This is a **Tentative Standard,** published for the purpose of eliciting criticism and suggestions, and as such is subject to annual revision.

ISSUED, 1927.

Scope. 1. These specifications cover the pigment commonly known as ultramarine blue. It may be purchased in the dry form or ground in oil or in japan to form a paste.

MANUFACTURE

Process. 2. (*a*) *Dry Pigment.*—The dry pigment shall be a manufactured blue approximating the composition of natural lapis lazuli. It shall be finely ground and of good blue color and free from admixtures of other substances.

(*b*) *Paste in Oil.*—The paste in oil shall be made by thoroughly grinding the specified pigment in pure raw or refined linseed oil.

(*c*) *Paste in Japan.*—The paste in japan shall be made by thoroughly grinding the specified pigment in high-grade grinding japan.

PROPERTIES AND TESTS

Composition and Properties. 3. (*a*) The mass color and character of the tint formed by mixture with a white pigment shall be the same as, and the strength not less than, that of a sample mutually agreed upon by the buyer and seller.

(*b*) *Dry Pigment.*—The dry pigment shall conform to the following requirements:

Coarse particles (total residue retained on a No. 325 screen[2]), maximum, per cent	1.0

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[1] Criticisms of these Tentative Specifications are solicited and should be directed to Mr. R. L. Hallett, Secretary of Committee D-1 on Preservative Coatings for Structural Materials, 105 York St., Brooklyn, N. Y.

[2] For determining coarse particles, screens 3 in. in diameter are recommended, conforming to the requirements of the Standard Specifications for Sieves for Testing Purposes (Serial Designation: E 11) of the American Society for Testing Materials, 1927 Book of A.S.T.M. Standards, Part II.

(*c*) *Paste in Oil.*—The paste in oil as received shall not be caked in the container and shall break up readily in oil to form a smooth paint of brushing consistency. It shall mix readily in all proportions, without curdling, with linseed oil, turpentine or volatile mineral spirits, or any mixture of these substances. The paste shall conform to the following requirements:

	MAXIMUM	MINIMUM
Pigment, per cent	....	70.0
Linseed oil, per cent	30.0	....
Moisture and other volatile matter, per cent	0.7	....
Coarse particles and skins (total residue retained on a No. 325 screen[1]), per cent	1.5	....

(*d*) *Paste in Japan.*—The paste as received shall not be caked in the container and shall break up readily in turpentine to form a smooth paint of brushing consistency, that will dry within one hour to a hard flat coat that can be varnished within five hours of the time of application without streaking or bleeding. The paste shall conform to the following requirements:

	MAXIMUM	MINIMUM
Pigment, per cent	....	70.0
Vehicle (japan), per cent	30.0	....
Coarse particles and skins (total residue retained on a No. 325 screen[1]), per cent	1.5	....
Non-volatile matter in the vehicle, per cent of the vehicle	....	40.0

NOTE.—The physical properties and tests of ultramarine blue, particularly the tinting strength, are considered a better measure of value than the percentage of chemical constituents.

Number of Tests.

4. One sample shall be taken at random from each lot of 1000 packages or fraction thereof. If the packages are of such size that 1000 amount to more than a carload, one sample shall be taken at random from each carload.

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[1] For determining coarse particles, screens 3 in. in diameter are recommended, conforming to the requirements of the Standard Specifications for Sieves for Testing Purposes (Serial Designation: E 11) of the American Society for Testing Materials, 1927 Book of A.S.T.M. Standards, Part II.

TENTATIVE SPECIFICATIONS
FOR
CHROME OXIDE GREEN[1]

Serial Designation: D 263 – 27 T

This is a **Tentative Standard,** published for the purpose of eliciting criticism and suggestions, and as such is subject to annual revision.

Issued, 1927.

Scope. 1. These specifications cover the pigment commonly known as chrome oxide green. The pigment may be purchased in the dry form or ground in oil to form a paste.

MANUFACTURE

General Composition. 2. (*a*) *Dry Pigment.*—The dry pigment shall consist of practically pure sesqui-oxide of chromium (Cr_2O_3) without any admixture.

(*b*) *Paste.*—The paste shall be made by thoroughly grinding the specified pigment in pure raw or refined linseed oil.

PROPERTIES AND TESTS

Composition and Properties. 3. (*a*) The mass color and character of the tint formed by mixture with a white pigment shall be the same as, and the strength shall be not less than that of a sample mutually agreed upon by the buyer and seller.

(*b*) *Dry Pigment.*—The dry pigment shall conform to the following requirements:

Total chromium (calculated as Cr_2O_3), minimum, per cent.....	97.0
Coarse particles (total residue retained on a No. 325 screen[2]), maximum, per cent..........	2.0

(*c*) *Paste.*—The paste as received shall not be caked in the container and shall break up readily in oil to form a smooth paint of brushing consistency. It shall mix readily, in all proportions, without curdling, with linseed oil, turpentine or volatile mineral spirits, or any mixtures of these substances. The paste shall conform to the following requirements:

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[1] Criticisms of these Tentative Specifications are solicited and should be directed to Mr. R. L. Hallett, Secretary of Committee D-1 on Preservative Coatings for Structural Materials, 105 York St., Brooklyn, N. Y.

[2] For determining coarse particles, screens 3 in. in diameter are recommended, conforming to the requirements of the Standard Specifications for Sieves for Testing Purposes (Serial Designation: E 11) of the American Society for Testing Materials, 1927 Book of A.S.T.M. Standards, Part II.

	MAXIMUM	MINIMUM
Pigment, per cent	..	85
Linseed oil, per cent	15	..
Coarse particles and skins (total residue retained on a No. 325 screen,[1] based on pigment), per cent	2.5	..

4. One sample shall be taken at random from each lot of 1000 packages or fraction thereof. If the packages are of such size that 1000 amount to more than a carload, one sample shall be taken at random from each carload. **Number of Tests.**

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[1] For determining coarse particles, screens 3 in. in diameter are recommended, conforming to the requirements of the Standard Specifications for Sieves for Testing Purposes (Serial Designation: E 11) of the American Society for Testing Materials, 1927 Book of A.S.T.M. Standards, Part II.

TENTATIVE SPECIFICATIONS
FOR
COMMERCIAL PARA RED[1]

Serial Designation: D 264 - 27 T

This is a **Tentative Standard,** published for the purpose of eliciting criticism and suggestions, and as such is subject to annual revision.

Issued, 1927.

Scope

1. These specifications cover a red paint pigment commonly known as commercial para red. The pigment may be purchased in the dry form or ground in oil or in japan to form a paste.

MANUFACTURE

Process.

2. (*a*) *Dry Pigment.*—The pigment shall be para nitraniline red toner, precipitated on a white base consisting of barium sulfate with or without siliceous materials.

(*b*) *Paste in Oil.*—The paste in oil shall be made by thoroughly grinding the specified pigment in pure raw or refined linseed oil.

(*c*) *Paste in Japan.*—The paste in japan shall be made by thoroughly grinding the specified pigment in high-grade grinding japan.

PROPERTIES AND TESTS

Composition and Properties.

3. (*a*) The mass color and character of the tint formed by mixture with a white pigment shall be the same as, and the strength shall be not less than that of a sample mutually agreed upon by the buyer and seller.

(*b*) *Dry Pigment.*—The dry pigment shall conform to the following requirements:

	Maximum	Minimum
Pure organic coloring matter (para red), per cent	..	10.0
Barium sulfate, per cent	..	60.0
Siliceous material	remainder	remainder
Coarse particles retained on a No. 325 screen,[2] per cent	1.5	..

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[1] Criticisms of these Tentative Specifications are solicited and should be directed to Mr. R. L. Hallett, Secretary of Committee D-1 on Preservative Coatings for Structural Materials, 105 York St., Brooklyn, N. Y.

[2] For determining coarse particles, screens 3 in. in diameter are recommended, conforming to the requirements of the Standard Specifications for Sieves for Testing Purposes (Serial Designation: E 11) of the American Society for Testing Materials, 1927 Book of A.S.T.M. Standards, Part II.

(*c*) *Paste in Oil.*—The paste as received shall not be caked in the container and shall break up readily in oil to form a smooth paint of brushing consistency. It shall mix readily in all proportions, without curdling, with linseed oil, turpentine or volatile mineral spirits, or any mixture of these substances. The paste shall conform to the following requirements:

	MAXIMUM	MINIMUM
Pigment, per cent	....	78.0
Linseed oil, per cent	22.0	....
Moisture and other volatile matter, per cent	0.7	....
Coarse particles and skins (total residue retained on a No. 325 screen,[1] based on pigment), per cent	2.0	....

(*d*) *Paste in Japan.*—The paste as received shall not be caked in the container and shall break up readily in turpentine to from a smooth paint of brushing consistency that will dry within one hour to a hard flat coat that can be varnished within five hours of the time of application, without streaking or bleeding. The paste shall conform to the following requirements:

	MAXIMUM	MINIMUM
Pigment, per cent	....	78.0
Vehicle (japan), per cent	22.0	....
Coarse particles and skins (total residue retained on a No. 325 screen,[1] based on pigment), per cent	2.0	....
Non-volatile matter in the vehicle, per cent of the vehicle	....	40.0

Number of Tests.

4. One sample shall be taken at random from each lot of 1000 packages or fraction thereof. If the packages are of such size that 1000 amount to more than a carload, one sample shall be taken at random from each carload.

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[1] For determining coarse particles, screens 3 in. in diameter are recommended, conforming to the requirements of the Standard Specifications for Sieves for Testing Purposes (Serial Designation: E 11) of the American Society for Testing Materials, 1927 Book of A.S.T.M. Standards, Part II.

TENTATIVE SPECIFICATIONS
FOR
TITANIUM BARIUM PIGMENT[1]

Serial Designation: D 265 – 27 T

This is a **Tentative Standard,** published for the purpose of eliciting criticism and suggestions, and as such is subject to annual revision.

ISSUED, 1927.

Scope.

1. These specifications cover titanium barium pigment in the dry form, also ground in oil to form a paste.

MANUFACTURE

General Composition.

2. (*a*) *Dry Pigment.*—The pigment shall consist of titanium oxide precipitated upon and coalesced with *blanc fixe* (precipitated barium sulfate).

(*b*) *Paste.*—The paste shall be made by thoroughly grinding the pigment in pure raw or refined linseed oil.

PROPERTIES AND TESTS

Composition and Properties.

3. (*a*) When specified, the color and color strength shall be equal to that of a sample mutually agreed upon by the buyer and seller.

(*b*) *Dry Pigment.*—The pigment shall be thoroughly washed and shall conform to the following requirements:

	MAXIMUM	MINIMUM
Coarse particles (total residue retained on a No. 325 screen[2]) per cent	1.0	....
Titanium oxide (TiO_2), per cent	....	24.0
Total impurities, including moisture, per cent	1.0	....
Barium sulfate	remainder	remainder

(*c*) *Paste.*—The paste as received shall not be caked in the container and shall break up readily in oil to form a smooth paint of brushing consistency. It shall mix readily in all proportions, without curdling, with linseed oil, turpentine or volatile mineral spirits, or any mixture of these substances. The paste shall conform to the following requirements:

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[1] Criticisms of these Tentative Specifications are solicited and should be directed to Mr. R. L. Hallett, Secretary of Committee D-1 on Preservative Coatings for Structural Materials, 105 York St., Brooklyn, N. Y.

[2] For determining coarse particles, screens 3 in. in diameter are recommended, conforming to the requirements of the Standard Specifications for Sieves for Testing Purposes (Serial Designation: E 11) of the American Society for Testing Materials, 1927 Book of A.S.T.M. Standards, Part II.

	MAXIMUM	MINIMUM
Pigment, per cent	....	80.0
Linseed oil, per cent	20.0	....
Moisture and other volatile matter, per cent	0.7	....
Coarse particles and "skins" (total residue retained on a No. 325 screen[1], based on pigment), per cent	1.5	....

Number of Tests.

4. One sample shall be taken at random from each lot of 1000 packages or fraction thereof. If the packages are of such size that 1000 amount to more than a carload, one sample shall be taken at random from each carload.

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[1] For determining coarse particles, screens 3 in. in diameter are recommended, conforming to the requirements of the Standard Specifications for Sieves for Testing Purposes (Serial Designation: E 11) of the American Society for Testing Materials, 1927 Book of A.S.T.M. Standards, Part II.

TENTATIVE SPECIFICATIONS
FOR
ALUMINUM POWDER FOR PAINTS[1]

Serial Designation: D 266 - 27 T

This is a **Tentative Standard,** published for the purpose of eliciting criticism and suggestions, and as such is subject to annual revision.

ISSUED, 1927.

Scope 1. These specifications cover the material produced by a stamping process and commonly known as "aluminum bronze powder." The product produced by a spraying operation, which consists of more or less nearly spherical particles, and is sometimes known in the trade as "aluminum powder," is not covered by these specifications.

PROPERTIES AND TESTS

Properties and Tests. 2. (*a*) The aluminum powder shall be suitable for making aluminum paint. It shall match in luster and fineness a sample mutually agreed upon by the buyer and seller.

(*b*) It shall contain no filler or adulterant, such as mica, and shall be commercially pure aluminum in the form of fine, polished flakes with not to exceed 3 per cent of fatty or oily matter (polishing lubricant).

(*c*) It shall have good "leafing" properties (by "leafing" is understood the property of forming an apparently continuous brilliant film over the entire free surface of a mixture of the powder in spar varnish within one minute after cessation of stirring the mixture).

(*d*) A residue of not more than 0.2 per cent shall be retained on a No. 100 sieve when the powder is washed through with alcohol. It shall "leaf" readily with spar varnish[2] and when mixed with such varnish in the proportion of 2 lb. to the gallon shall give a free flowing, smooth, continuous coating.

Number of Tests. 3. One sample shall be taken at random from each lot of 1000 packages or fraction thereof for purpose of test.

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[1] Criticisms of these Tentative Specifications are solicited and should be directed to Mr. R. L. Hallett, Secretary of Committee D-1 on Preservative Coatings for Structural Materials, 105 York St., Brooklyn, N. Y.

[2] Federal Specifications Board Specification No. 186, Varnish, Spar, Water-Resisting.

TENTATIVE SPECIFICATIONS
FOR
GOLD BRONZE POWDER[1]

Serial Designation: D 267 - 27 T

This is a **Tentative Standard,** published for the purpose of eliciting criticism and suggestions, and as such is subject to annual revision.

ISSUED, 1927.

Scope. 1. These specifications cover the materials commonly known as gold bronze, pale gold bronze, and rich gold bronze powders.

PROPERTIES AND TESTS

Composition and Properties. 2. (*a*) The gold bronze powder shall be suitable for making gold bronze paint. It shall match in shade and fineness a sample mutually agreed upon by the buyer and seller.

(*b*) It shall be made from new ingot metals and the finished powder shall consist essentially of copper and zinc. It shall consist of fine polished flakes with not to exceed 3 per cent of fatty or oily matter (polishing lubricant) to give good "leafing" properties.

(*c*) It shall "leaf" readily with spar varnish and ordinary bronzing liquids, and when mixed in the proportion of 3½ to 4 lb. to a gallon, shall give a free flowing, smooth, continuous coating.

(*d*) A residue of not more than 0.1 per cent shall be retained on a No. 100 sieve.

Number of Tests. 3. One sample shall be taken at random from each lot of 1000 packages or fraction thereof for purpose of test.

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[1] Criticisms of these Tentative Specifications are solicited and should be directed to Mr. R. L. Hallett, Secretary of Committee D-1 on Preservative Coatings for Structural Materials, 105 York St., Brooklyn, N. Y.

TENTATIVE METHODS
OF
TESTING SHELLAC VARNISH[1]

Serial Designation: D 214 – 27 T

This is a **Tentative Standard,** published for the purpose of eliciting criticism and suggestions, and as such is subject to annual revision.

ISSUED, 1925; REVISED, 1926, 1927.

Shellac varnishes are made by dissolving shellac in alcohol and are designated in the trade in terms of pounds of shellac per gallon of alcohol, the 4, 4.5 and 5-lb. cut goods being most commonly used. Specially denatured alcohol (Formula No. 1) is largely used, and occasionally wood alcohol and butyl alcohol are used. Pure grain alcohol, or Formula No. 35 denatured, is used for confectioner's varnish or glaze.

GENERAL

1. (*a*) All tests, unless otherwise stated, shall be made at room temperature between 21 and 32° C. (70 and 90° F.).

(*b*) The sample of shellac varnish shall be thoroughly agitated in the container immediately before portions are removed for the various tests and the unused portion shall be kept in a tightly stoppered glass container, in a dark place.

DETERMINATION OF COLOR

2. The color of the well-shaken sample shall be compared with the color of the well-shaken sample of shellac varnish mutually agreed upon for color by the buyer and seller. The color comparison shall be made in clear glass tubes of the same diameter.

DETERMINATION OF NON-VOLATILE MATTER

Method (*a*). APPARATUS

3. The apparatus shall consist of the following:

(*a*) A weighing bottle for volatile liquids or a Grethan pipette.

(*b*) A tin-foil dish, approximately 1¼ in. in height and 2½ in. in diameter.

(*c*) Prepared Sand, prepared as follows: Sieve sea-sand to remove any foreign material. Digest with hot HCl for about one hour.

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[1] Criticisms of these Tentative Methods are solicited and should be directed to Mr. R. L. Hallett, Secretary of Committee D-1 on Preservative Coatings for Structural Materials, 105 York St., Brooklyn, N. Y.

Wash with water to remove all the acid and soluble impurities. Ignite and put in a desiccator to cool. Preserve in a tightly stoppered bottle.

PROCEDURE

Procedure.

4. Put 10 g. of the prepared sand and a short glass rod in the tin-foil dish. Record the exact weight of the dish and contents. Transfer about 1 g. of the sample from the weighing bottle to the dish. Record the exact weight of the sample taken which will be the difference in weight of the weighing bottle before and after the removal of the sample. Thoroughly mix the varnish and sand with the glass rod and place the dish in an oven maintained at 105° C. for one hour. Remove the dish from the oven, allow it to cool and weigh. The increase in weight of the tin-foil dish containing the sand and glass rod is the weight of the non-volatile matter in the sample of varnish taken.

Method (*b*).

5. Follow the procedure given in the Standard Methods of Testing Oleo-Resinous Varnishes (Serial Designation: D 154) of the American Society for Testing Materials,[1] for non-volatile matter in oleo-resinous varnish, with the exception that the weight of sample taken shall not exceed 1.5 g. With varnishes made by "cutting" over 5 lb. of shellac per gallon of alcohol, add 10 g. of sea sand, prepared as described in Section 3 (*c*), to the container and mix with the sample by means of a short glass rod (previously weighed with the container and sand).

Calculation of Body.

6. (*a*) Since bone dry white shellac may lose up to 5 per cent of its weight when heated at 105° C., the weight of non-volatile matter found in the case of white shellac varnish should be divided by the factor 0.95.

(*b*) On account of the efforts of the orange varnish manufacturers to produce cleaner varnish for the trade by the use of centrifuge machines and improved filtration apparatus, the same allowance of 5 per cent, which is made in calculating white shellac varnish body, shall be used in determining clarified orange varnish body. This 5-per-cent allowance is based on the fact that 2 per cent of moisture has always been allowed in the calculation, and in addition the 3 per cent of insoluble matter customarily encountered in varnish grades of orange shellac is eliminated by the modern methods of varnish production.

The calculations of the body of white and orange shellac varnishes are made according to the methods shown in the following examples:

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[1] 1927 Book of A.S.T.M. Standards, Part II.

Example.—

White Shellac Varnish and Clarified Orange Shellac Varnish:

Weight of varnish taken........................ 1.2973 g.

Weight of residue (after drying).................. 0.5235 g.

$$\text{Per cent of body} = \frac{0.5235}{0.95 \times 1.2973} \times 100 = 42.45 \text{ per cent}$$

This percentage corresponds to 5 lb. per gallon.

The above orange-varnish calculation refers to ready-cut varnish as obtained in the regular paint and varnish shops.

The better grades of orange shellac, which contain little insoluble matter, can and are cut in alcohol and simply strained through an 80-mesh screen. Such a varnish would contain practically all the finely divided inert matter and the calculation of the body of such a varnish would be made as follows:

Since dry orange shellac may lose up to 2 per cent of its weight when heated at 105° C., the weight of non-volatile matter found in the case of orange shellac varnish should be divided by the factor 0.98.

The calculation of the body is made according to the method shown in the following example:

Example.—

Unclarified Orange Shellac Varnish:

Weight of varnish taken........................ 1.3200 g.

Weight of residue (after drying).................. 0.5491 g.

$$\text{Per cent of body} = \frac{0.5491}{0.98 \times 1.3200} \times 100 = 42.45 \text{ per cent.}$$

This percentage corresponds to 5 lb. per gallon.

(*c*) To convert the percentage of solids (residue) of the varnish into pounds per gallon, from the percentage of solids expressed in pounds of solids in 100 lb. of varnish, the pounds of solvent is found by difference. The weight of solvent divided by 6.7793 (the weight of one gallon of denatured alcohol (Formula No. 1) at 16° C. (60° F.), gives the number of gallons of alcohol present. From this the number of pounds of shellac per gallon of alcohol is determined.

Example.—

100 – 30.68 (solids found) = 69.32 lb. of alcohol

$$\frac{69.32}{6.7793} = 10.23 \text{ gallons of alcohol.}$$

$$\frac{30.68}{10.23} = 3 \text{ lb. per gallon.}$$

For convenience, tables are appended hereto giving pounds of shellac per gallon for varnishes for various specific gravities.

DETERMINATION OF MATTER INSOLUBLE IN HOT ALCOHOL

7. (*a*) Matter insoluble in hot alcohol shall be determined by the continuous extraction method or by the Gooch filtration method as described in the Standard Methods of Testing Shellac (Serial Designation: D 29) of the American Society for Testing Materials.[1]

(*b*) In the case of the continuous-extraction method, weigh an amount of shellac varnish corresponding, as closely as practicable, to 5 g. of non-volatile matter, while with the Gooch filtration method take a weight of sample corresponding closely to 2 g. of non-volatile matter.

DETERMINATION OF WAX

8. In the determination of wax, dilute an amount of the varnish that will contain approximately 10 g. of dry shellac with 95-per-cent specially-denatured alcohol to about 200 cc. and proceed in accordance with the method for determining wax as described in the Standard Methods of Testing Shellac (Serial Designation: D 29) of the American Society for Testing Materials.[1]

DETERMINATION OF PURITY

A. Qualitative Tests

9. (*a*) *Copal.*—Filter some of the varnish through dry paper into a large test tube (6 by $\frac{3}{4}$ in.). To 10 cc. of the filtrate add 99-per-cent methyl alcohol to nearly fill the tube and thoroughly mix. The formation of a precipitate after standing is an indication of copal. Shellac free from copal should remain clear under the conditions given above.

(*b*) *Rosin.*—Add 20 cc. of absolute alcohol or glacial acetic acid (melting point 13 to 14° C.) to 5 cc. of the varnish and thoroughly mix. Add 100 cc. of petroleum ether and again thoroughly mix. Add approximately 2 liters of water and separate a portion of the ether layer (at least 50 cc.) and filter if cloudy. Evaporate the petroleum ether and test the residue by the Halphen-Hicks reagent as follows:

Solution A.—One part by volume of phenol dissolved in 2 parts of carbon tetrachloride.

Solution B.—One part by volume of bromine dissolved in 4 parts of carbon tetrachloride.

Add 1 to 2 cc. of solution A to the residue left after evaporation of the petroleum ether solution. Pour this solution into a cavity of an ordinary porcelain color reaction plate and fill an adjacent cavity with solution B. Cover the plate with a watch glass and note the color, if any, produced by the action of bromine vapors on solution A. A decided purple or blue color is an indication of rosin.

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[1] 1927 Book of A.S.T.M. Standards, Part II.

B. Determination of Iodine Number

Method (a).

Procedure. 10. (*a*) With the percentage of solids known, weigh accurately in a suitable pipette, or weighing bottle for volatile liquids, an amount of varnish corresponding to 0.20 g. of dry shellac and transfer to a 250-cc. glass-stoppered bottle. In case heavy adulteration is suspected, weigh an amount of varnish corresponding to 0.15 g. of shellac or less if necessary.

(*b*) Warm the bottle in a water bath at a temperature of 75 to 80° C. for about 15 minutes, aspirating the alcohol vapor until the residue is practically dry. Cool and add 20 cc. of acetic acid (melting point, 14.8° C.). Proceed in accordance with the method for iodine number as described in the determination of rosin in the Standard Methods of Testing Shellac (Serial Designation: D 29) of the American Society for Testing Materials.[1]

Method (b).

Alternate Procedure. 11. Transfer about 1.5 cc. of the varnish by means of a pipette to a flat-bottomed glass or porcelain dish at least 8 cm. in diameter. Add 1 to 2 cc. of 95-per-cent alcohol to spread the varnish evenly over the bottom of the dish. Heat the dish and contents at 75 to 80° C. for one-half hour. Scrape the residue from the dish, accurately weigh 0.20 g., and transfer to a 250-cc. glass-stoppered bottle. In case of badly adulterated samples, a proportionately smaller weight of sample should be taken. Proceed in accordance with the method for iodine number described in the determination of rosin in the Standard Methods of Testing Shellac (Serial Designation: D 29) of the American Society for Testing Materials.[1]

12. (*a*) If a qualitative test shows the presence of copal but no rosin, the amount may be estimated from iodine number, taking the iodine number of copal as 130 and making the calculation in an analogous manner to that for rosin described in Section 7 of the Standard Methods D 29.

(*b*) If a qualitative test shows the presence of rosin but no copal, the calculation of the percentage of rosin may be made as described in Section 7 of the Standard Methods D 29.

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[1] 1927 Book of A.S.T.M. Standards, Part II.

APPENDIX

Information concerning the volatile portion of a shellac varnish may be obtained by distilling approximately 50 cc. of varnish to dryness (avoiding decomposition of the shellac through excessive heat at the end) and determining the boiling range of this distillate by a redistillation. A portion of the final distillate may be diluted with water to ascertain if other solvents, such as naphtha or benzol, have been added. These will separate on dilution and the layer formed may be measured.

RELATION OF POUNDS OF SHELLAC PER GALLON TO SPECIFIC GRAVITY, TAKING WEIGHT OF WATER 1 GAL. = 8.33 LB.

WHITE SHELLAC VARNISH: DRY BLEACHED SHELLAC (5 PER CENT MOISTURE), DENATURED ALCOHOL, FORMULA NO. 1, 95-PER-CENT

SHELLAC, LB. PER GAL. OF ALCOHOL	SPECIFIC GRAVITY 15.5° C. (60° F.)	DEG. BAUMÉ	WEIGHT PER 1 GAL. VARNISH, LB.
3	0.9056	24.60	7.544
3.5	0.9167	22.70	7.636
4	0.9278	20.90	7.729
4.5	0.9375	19.33	7.809
5	0.9464	17.92	7.884
5.5	0.9530	16.90	7.938
6	0.9597	15.90	7.994

ORANGE SHELLAC VARNISH: TN SHELLAC (2 PER CENT MOISTURE), DENATURED ALCOHOL, FORMULA NO. 1, 95-PER-CENT.

3	0.900	25.55	7.497
3.5	0.9114	23.6	7.592
4	0.9228	21.7	7.687
4.5	0.9318	20.25	7.762
5	0.9395	19.0	7.826
5.5	0 9500	17.36	7.914
6	0.9554	16.53	7.958

NOTE 1.—Shellac varnishes will not always agree exactly with the specific gravity given above, estimated at 15.5° C. (60° F.). They will vary somewhat, due to more or less moisture and insoluble matter contained in the white and orange shellacs and also to loss of solvent by evaporation. However, the figures given agree closely with theoretical and practical results.

NOTE 2.—If 10 lb. of shellac is cut in 1 gal. of alcohol the yield is 2 gal. of varnish, hence 10 lb. of shellac cut in alcohol is equivalent to 1 gal.

Example.—

4 lb. shellac cut in 1 gal. alcohol yields 1.4 gal. varnish
4½ lb. " " " " " " " 1.45 " "
5 lb. " " " " " " " 1.50 " "

The following table shows corresponding percentages of gum and alcohol in shellac varnishes of the following pounds of gum cut per gallon, No. 1 Specially Denatured Alcohol 95-per-cent, by volume at 15.5° C. (60° F.)[a]

Pounds of Gum per Gallon of Alcohol	Gum, per cent	Alcohol, per cent
3.0	30.68	69.32
3.25	32.41	67.59
3.50	34.05	65.95
3.75	35.61	64.39
4.0	37.11	62.89
4.25	38.54	61.45
4.50	39.90	60.10
4.75	41.20	58.80
5.0	42.45	57.55
5.25	43.65	56.35
5.50	44.79	55.21
5.75	45.89	54.11
6.0	46.98	53.02

The weight of 1 gal. of alcohol (No. 1 Special) at 15.5° C. (60° F.) is 6.7793 lb. according to Regulations No. 61, U. S. Internal Revenue.

The table given above is taken from the Official Booklet of the United States Shellac Importers' Association.

NOTE 3.—Method (*a*) covering Determination of Non-Volatile Matter in Varnish is the official method of the United States Shellac Importers' Association.

NOTE 4.—The above figures are the most important in the tables to the varnish industry as considerable shellac varnish is now sold by weight, or the gallonage is determined by dividing the net weight by its corresponding factor.

NOTE 5.—Hydrometers should not be employed to determine the specific gravity or degrees Baumé of a shellac varnish, as readings so obtained are unreliable and inaccurate. The specific gravity of a shellac varnish can be accurately determined either with a specific gravity bottle (pyknometer) or by weighing accurately 100 cc. of the varnish at 15.5°C. (60° F.) in a 100-cc. graduated flask, which has been calibrated with distilled water at the same temperature.

TENTATIVE METHOD OF TEST
FOR
DETERMINATION OF WAX IN SHELLAC[1]
("MACHINE-MADE" AND DRY-BLEACHED REFINED SHELLAC)

Serial Designation: D 29 - 27 T

This is a **Tentative Standard,** published for the purpose of eliciting criticism and suggestions, and as such is subject to annual revision.

ISSUED, 1927.

1. Dissolve 10 g. of shellac with 2.5 g. of carbonate of soda and 150 cc. of hot water. Make the solution in a 200-cc. tall form beaker; immerse the beaker in a steam or boiling-water bath and stir till the shellac is in solution. Then cover with a watch glass, allow to remain in the water bath for 2 or 3 hours more without agitation, remove beaker from the bath and stand in cold water. The wax will form a layer at the top. Filter the solution through a 12-cm. folded filter paper, or a Buchner funnel (2¼ or 3½ in. in inside diameter) may be used. Cover the bottom of the funnel with a disk of filter paper, mix 1 g. of filter cell with water and pour on the filter. Add 0.5 g. of filter cell to the solution, and filter with the aid of a vacuum. After washing out the soluble shellac pour on a few cubic centimeters of alcohol to facilitate drying. When dry, remove the filter bed and wrap in filter paper, and extract in suitable continuous extraction apparatus with chloroform or carbon tetrachloride for 1½ to 2 hours. Dry the wax at 105° C. to constant weight.

NOTE.—The filter cell used should be extracted with either of the solvents, chloroform or carbon tetrachloride.

2. In the case of dry-bleached refined shellac, dissolve 50 g. in 250 cc. of alcohol, add 1 g. of oxalic acid and stir till all is dissolved. Then, add 0.5 g. of filter cell and allow to settle over night. Run the clear liquor through a Gooch crucible prepared with asbestos. Wash the sediment of wax and filter cell on the crucible with alcohol. Dry at a low temperature, remove the asbestos mat, wrap in filter paper and extract in continuous extraction apparatus with chloroform or carbon tetrachloride. Dry the wax at 105° C. to constant weight.

NOTE.—The carbon tetrachloride and chloroform should be redistilled before using, as they must not leave a non-volatile residue.

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[1] Criticisms of this Tentative Method are solicited and should be directed to Mr. R. L. Hallett, Secretary of Committee D-1 on Preservative Coatings for Structural Materials, 105 York St., Brooklyn, N. Y.

This tentative method, when adopted as standard, will be added to the present Standard Methods of Testing Shellac (Serial Designation: D 29 - 25), 1927 Book of A.S.T.M. Standards, Part II.

TENTATIVE METHODS OF SAMPLING AND TESTING LACQUER SOLVENTS AND DILUENTS[1]

Serial Designation: D 268 – 27 T

This is a **Tentative Standard,** published for the purpose of eliciting criticism and suggestions, and as such is subject to annual revision.

ISSUED, 1927.

Scope. 1. These methods cover the sampling and tests to be applied to solvents and diluents for use in the manufacture of nitro-cellulose lacquer.

SAMPLING

Sampling. 2. (*a*) The method of sampling specified in Paragraph (*b*) or (*c*) shall be used, according to the special conditions that obtain.

(*b*) *From Loaded Tank Car or Other Large Vessel.*—The composite sample taken shall not be less than ½ gal. and should consist of small samples of not more than 1 qt. each, taken from near the top and bottom by means of a metal or glass container with removable stopper or top. This device, attached to a suitable pole, shall be lowered to the desired depth, when the stopper or top shall be removed and the container allowed to fill.

(*c*) *Barrels and Drums.*—At least 5 per cent of the packages in any shipment shall be represented in the sample. The purchaser may increase the percentage of packages to be sampled at his discretion, and it is recommended that every package be sampled in the case of expensive solvents that are bought in small quantity. A portion shall be withdrawn from about the center of each package sampled by means of a "thief" or other sampling device. The composite sample thus obtained shall not be less than 1 qt. and shall consist of equal portions of not less than ½ pt. from each package sampled.

METHODS OF TESTING

Specific Gravity. 3. Specific gravity shall be determined for all solvents and diluents. The determination shall be made at 20° C. by any convenient method that is accurate to the third decimal point.

Color. 4. Color shall be determined for all solvents and diluents. The sample and the standard mutually agreed upon by the buyer and seller shall be compared in 50-cc. Nessler tubes against a white background. For a solvent to be rated water-white, the visible color shall not be darker than a solution of 0.0030 g. of potassium bichromate in one liter of water.

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[1] Criticisms of these Tentative Methods are solicited and should be directed to Mr. R. L. Hallett, Secretary of Committee D-1 on Preservative Coatings for Structural Materials, 105 York St., Brooklyn, N. Y.

Distillation. 5. The distillation test shall be conducted on all solvents and diluents, in accordance with the Standard Method of Test for Distillation of Gasoline, Naphtha, Kerosine, and Similar Petroleum Products (Serial Designation: D 86) of the American Society for Testing Materials,[1] except that the observations made shall be not of volumes of distillate coming over at certain specified temperatures, but of the temperatures at which certain specified volumes of the distillate come over. The temperature shall be observed and recorded at first drop of the distillate, and when the volume of the distillate collected, observed to the nearest 0.5 cc., reaches 5 cc., 10 cc., 20 cc., 30 cc., 40 cc., 50 cc., 60 cc., 70 cc., 80 cc., 90 cc., 95 cc., and end point.

Residue. 6. The residue shall be determined for all solvents and diluents. Using a pipette, 5 cc. of the sample and of the standard shall be placed in separate porcelain evaporating dishes. These samples shall be allowed to evaporate in a hood for 24 hours. If any residue remains, its nature shall be noted and the test for non-volatile matter shall be made as described in Section 7.

Non-volatile Matter. 7. Non-volatile matter of solvents and diluents shall be determined only when its presence is indicated by the results obtained in Section 6. One hundred cubic centimeters of the sample shall be placed in a weighed porcelain evaporating dish and evaporated almost to dryness on a steam bath. It shall then be heated in an oven at 100 to 110° C. to constant weight. The increase in the weight of the dish is the non-volatile matter of the sample, which should be expressed as a percentage, calculating the weight of the sample from its specific gravity, determined as described in Section 3.

Residual Odor. 8. Residual odor shall be determined for all solvents and diluents in which residual odor is an important property. Strips of heavy filter paper, of the same size and shape, shall be dipped to the same depth in beakers or wide-mouthed bottles containing the sample and the standard. They shall then be attached to a piece of wood with thumb tacks and at suitable intervals examined for difference in odor.

Water. 9. Water shall be determined for all solvents and diluents. Five cubic centimeters of the sample shall be transferred to a 100-cc. glass-stoppered cylinder, and 60° Baumé gasoline added in 5-cc. portions, shaking well after each addition. Water is indicated by turbidity. If turbidity develops, the standard shall be tested in the same way and compared.

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[1] 1927 Book of A.S.T.M. Standards, Part II.

Acidity. 10. Acidity shall be determined for all solvents and diluents. Using a pipette, 50 cc. of the sample shall be transferred to a small Erlenmeyer flask and titrated with 0.1 *N* KOH in 99-per-cent methyl alcohol, using phenolphthalein as an indicator. The weight of the sample shall be determined from the specific gravity and the acidity reported as milligrams of KOH per gram of sample.

Alkalinity. 11. Alkalinity of solvents and diluents shall be determined only when indicated by the results obtained in Section 10. Using a pipette, 50 cc. of the sample shall be transferred to a small Erlenmeyer flask and titrated with 0.1 *N* H_2SO_4, using methyl orange as an indicator. The weight of the sample shall be determined from its specific gravity and the alkalinity reported as milligrams of KOH per gram of sample.

Ester Value. 12. Ester value shall be determined for all esters. One to two grams of the sample shall be weighed in an ampoule, by first weighing the empty ampoule, warming and filling, and then sealing-off and reweighing. The ampoule shall be placed in a 200-cc. Erlenmeyer flask which contains 50 cc. of approximately 0.5 *N* alcoholic KOH. The ampoule should be broken with a stirring rod and the flask connected with a reflux condenser. The flask shall then be heated on a steam bath for one to four hours, depending upon the ester being tested. During the heating the set-up and contents should be shaken frequently, taking the usual precautions to lose none of the contents. After the apparatus has cooled, the condenser shall be washed down with distilled water and three drops of phenolphthalein added to the contents of the flask as an indicator. The contents of the flask shall be titrated with 0.5 *N* HCl. Two blanks with alcoholic KOH shall be run along with the sample. These blanks should check to the first decimal point. The result shall be reported as percentage of ester by weight, allowing in the calculations for acidity or alkalinity as determined in Sections 10 and 11.

NOTE.—An optional method of weighing the sample is in a small weighing bottle, removing the stopper after introduction into the flask with a stirring rod, or by agitating the contents of the flask. Apparatus with glass joints should be used if available.

Copper Corrosion Test. 13. A copper corrosion test shall be run on solvents and diluents derived from coal tar and petroleum. A clean strip of mechanically polished pure sheet copper, about 1 in. square, shall be placed in a 4-in. porcelain evaporating dish and covered with 100 cc. of the sample. This shall be covered with a watch glass and heated on a steam bath for 30 minutes. The liquid shall be poured off and the copper examined for blackening. A slight tarnish shall be disregarded, but any marked blackening shall be cause for rejection.

TENTATIVE METHODS OF ROUTINE ANALYSIS OF WHITE LINSEED OIL PAINTS[1]

Serial Designation: D 215 - 27 T

This is a **Tentative Standard,** published for the purpose of eliciting criticism and suggestions, and as such is subject to annual revision.

ISSUED, 1925; REVISED, 1927.

PRELIMINARY PROCEDURE

On receipt of a sample make a record of the label, noting especially the brand, the name of the manufacturer, and any statement as to composition and net contents. Weigh the unbroken package, open, note odor and condition of the contents, pour into a clean container, and mix thoroughly by pouring from one container to the other, finally leaving the well-mixed sample in the second container, which shall be tightly closed. The well-mixed sample is used at once for the determinations described under "Methods." The original can and cover may be cleaned with gasoline, wiped dry, and then weighed. This weight subtracted from the original weight will give the net weight of the contents. If desired, the specific gravity of the paint may be determined and the weight per gallon calculated, and the volume of paint and the capacity of the container may be measured.

REAGENTS REQUIRED

Extraction Mixture.—10 volumes ether (ethyl ether);
6 volumes benzol;
4 volumes methyl alcohol;
1 volume acetone.

Aqueous Sodium Hydroxide.—Dissolve 100 g. of NaOH in distilled water and dilute to 300 cc.

Alcoholic Sodium Hydroxide Solution.—Dissolve pure NaOH in 95-per-cent ethyl alcohol in the proportion of about 22 g. per 1000 cc. Let stand in a stoppered bottle. Decant the clear liquid into another bottle and keep well stoppered. This solution should be colorless or only slightly yellow when used, and it will keep colorless longer if the alcohol is previously treated with sodium hydroxide (about 80 g. to 1000 cc.), kept at about 50° C. for 15 days, and then distilled.

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[1] Criticisms of these Tentative Methods are solicited and should be directed to Mr. R. L. Hallett, Secretary of Committee D-1 on Preservative Coatings for Structural Materials, 105 York St., Brooklyn, N. Y.

Wijs Solution.—Dissolve iodine in glacial acetic acid that has a melting point of 14.7 to 15° C. and is free from reducing impurities in the proportion so that 13 g. of iodine will be present in 1000 cc. of solution. The preparation of the iodine monochloride solution presents no great difficulty but it shall be done with care and accuracy in order to obtain satisfactory results. There shall be in the solution no sensible excess either of iodine or more particularly of chlorine over that required to form the monochloride. This condition is most satisfactorily attained by dissolving in the whole of the acetic acid to be used the requisite quantity of iodine, using a gentle heat to assist the solution, if it is found necessary. Set aside a small portion of this solution while pure, and pass dry chlorine into the remainder until the halogen content of the solution is doubled. Ordinarily, it will be found that by passing the chlorine into the main part of the solution until the characteristic color of free iodine has just been discharged, there will be a slight excess of chlorine which is corrected by the addition of the requisite amount of the unchlorinated portion until all free chlorine has been destroyed. A slight excess of iodine does little or no harm, but excess of chlorine must be avoided.

Standard Sodium Thiosulfate Solution.—Dissolve pure sodium thiosulfate in distilled water (that has been well boiled to free it from carbon dioxide) in the proportion of 24.83 g. crystallized sodium thiosulfate to 1000 cc. of the solution. It is best to let this solution stand for about two weeks before standardizing. Standardize with pure resublimed iodine, pure potassium biiodate, or pure KIO_3 (see Treadwell-Hall, Analytical Chemistry, Vol. 2.) This solution will be approximately 0.1 *N*, and it is best to leave it as it is after determining its exact iodine value, rather than to attempt to adjust it to exactly 0.1 *N*. Preserve in a stock bottle provided with a guard tube filled with soda lime.

Starch Solution.—Stir up 2 to 3 g. of potato starch or 5 g. of soluble starch with 100 cc. of 1-per-cent salicylic acid solution, add 300 to 400 cc. of boiling water, and boil the mixture until the starch is practically dissolved, then dilute to 1 liter.

Potassium Iodide Solution.—Dissolve 150 g. of potassium iodide free from iodate in distilled water and dilute to 1000 cc.

Acid Ammonium Acetate Solution.—Mix 150 cc. of 80-per-cent acetic acid, 100 cc. of water, and 95 cc. of strong ammonia (sp. gr. 0.90).

Ammonium Polysulfide.—Pass H_2S gas into 200 cc. of strong ammonium hydroxide (sp. gr. 0.90) in a bottle immersed in running water or in iced water until the gas is no longer absorbed; then add 200 cc. of strong ammonium hydroxide (sp. gr. 0.90) and dilute with water to 1000 cc. Digest this solution with 25 g. of flowers of sulfur for several hours and filter.

"Lead Acid."—Mix 300 cc. of H_2SO_4 (sp. gr. 1.84) and 1800 cc. of distilled water. Dissolve 1 g. of c. p. lead acetate in 300 cc. of distilled water and add this to the hot solution, stirring meanwhile. Let stand at least 24 hours and siphon through a thick asbestos filter.

Potassium Permanganate Solution.—Dissolve 3.2 g. of pure potassium permanganate in a liter of distilled water, let stand 8 to 14 days, siphon off the clear solution (or filter through an asbestos filter), and standardize as follows: In a 400-cc. beaker dissolve 0.25 to 0.30 g. (accurately weighed) of Bureau of Standards' sodium oxalate in 250 cc. of hot water (80 to 90° C.) and add 15 cc. of dilute sulfuric acid (1:1). Titrate at once with the potassium permanganate solution, stirring the liquid vigorously and continuously. The permanganate must not be added more rapidly than 10 to 15 cc. per minute, and the last 0.5 to 1 cc. must be added dropwise with particular care to allow each drop to be fully decolorized before the next is introduced. The temperature of the solution should not be below 60° C. by the time the end point is reached. (Too rapid cooling may be prevented by allowing the beaker to stand on a small asbestos-covered hot plate during the titration. The use of a small thermometer as a stirring rod is most convenient.) The weight of sodium oxalate used multiplied by 0.833 gives its iron equivalent. The permanganate solution should be kept in a glass stoppered bottle painted black to keep out light.

The iron (Fe) value of the $KMnO_4$ multiplied by 1.076 theoretically equals its antimony (Sb) equivalent. However, for use in determining antimony, the $KMnO_4$ is best standardized as follows: To 0.25 g. of pure metallic antimony in a 500-cc. Pyrex Erlenmeyer flask, add 12 to 15 cc. of concentrated H_2SO_4 and 10 to 12 g. of K_2SO_4; heat until all the antimony is dissolved, cool, dilute to 250 cc. with water, add 20 cc. of concentrated HCl, cool to 10 to 15° C., and titrate with the $KMnO_4$ solution until a faint pink color is obtained. For special work, after digesting, dilute to 100 cc. with water, add 1 to 2 g. of Na_2SO_3, and boil until all the SO_2 is expelled. This is shown when no blue color is obtained with starch-iodate paper (see below); the volume will be reduced about one-half. Dilute to 250 cc. with water, add 20 cc. of HCl (sp. gr. 1.19), and complete as described.

Standard Potassium Ferrocyanide.—Dissolve 22 g. of the pure salt in water and dilute to 1000 cc. To standardize, transfer about 0.2 g. (accurately weighed) of pure metallic zinc or freshly ignited pure zinc oxide to a 400-cc. beaker. Dissolve in 10 cc. of HCl and 20 cc. of water. Drop in a small piece of litmus paper, add ammonium hydroxide until slightly alkaline, then add HCl until just acid, and then 3 cc. of strong HCl. Dilute to about 250 cc. with hot water and heat nearly to boiling. Run in the ferrocyanide solution slowly from a burette with constant stirring until a drop tested on a white porcelain plate with a drop of the uranyl indicator shows a brown tinge after standing one minute. A blank should be run with the same amounts of reagents and water as in the standardization. The amount of ferrocyanide solution required for the blank should be subtracted from the amounts used in standardization and in titration of the sample. The standardization must be made under the same conditions of temperature, volume, and acidity as obtained when the sample is titrated.

Uranyl Indicator for Zinc Titration.—A 5-per-cent solution of uranyl nitrate in water or a 5-per-cent solution of uranyl acetate in water made slightly acid with acetic acid.

Alkaline Lead Nitrate Solution.—Into 100 cc. of KOH solution (56 g. in 140 cc. of water) pour a saturated solution of lead nitrate (250 g. in 500 cc. of water) until the precipitate ceases to redissolve, stirring constantly while mixing. Let settle, filter through asbestos, and dilute the clear filtrate with an equal volume of water. About 3 volumes of the lead nitrate solution will be required for one of the KOH.

Ammoniacal Cadmium Chloride or Zinc Sulfate Solution.—Dissolve 8 g. of cadmium chloride in 200 cc. of water and add 200 cc. of NH_4OH (sp. gr. 0.90), or, dissolve 200 g. of zinc sulfate in 1080 cc. of water and 920 cc. of NH_4OH (sp. gr. 0.90).

Standard Potassium Iodate Solution.—Dissolve 3.6 g. of KIO_3 and 39 g. of KI in 1000 cc. of water. For general work the theoretical sulfur titer of this solution should be used; for special work, the solution may be standardized against like material, such as a lithopone of known sulfide sulfur content. The theoretical titer is based on standard $Na_2C_2O_4$ and is obtained as follows: To 300 cc. of water in a 600-cc. flask, preferably glass stoppered, add 10 cc. of concentrated HCl (sp. gr. 1.19) and 1 g. of KI. Cool and add 10 cc. of 0.1 N $KMnO_4$ solution which has been standardized against $Na_2C_2O_4$. Swirl gently, stopper, and let stand for five minutes. Titrate the liberated iodine with standard $Na_2S_2O_3$ solution until the color fades. Then add 10 cc. of starch solution and continue the titration until the blue color is destroyed. Repeat the titration with the sole difference that 10 cc.

of the iodate solution is substituted for the $KMnO_4$ solution. Calculate the normality of the iodate solution.

Starch Indicator for Sulfur Titration.—(1) To 1000 cc. of boiling water, add a cold suspension of 6 g. of starch in 100 cc. of water and boil vigorously for five minutes. Cool the solution, add 6 g. of $ZnCl_2$ dissolved in 50 cc. of cold water, thoroughly mix and set aside for 24 hours. Decant the clear supernatant liquid into a suitable container, add 3 g. of KI, and mix thoroughly. (2, Optional.) Prepare an emulsion of 6 g. of soluble starch in 25 cc. of water, add a solution of 1 g. of NaOH in 10 cc. of water, and stir the solution until it gelatinizes. Dilute to 1000 cc. with water, add 3 g. of KI, and mix thoroughly.

Starch-Iodate Paper.—Impregnate filter paper with a solution obtained by heating 2 g. of starch with 100 cc. of water, and, after solution, adding 0.2 g. of KIO_3 dissolved in 5 cc. of water.

Standard Iodine Solution for SO_2.—Place 15 to 20 g. of pure KI in a liter flask, dissolve in as little water as possible, and then add about 6.4 g. of resublimed iodine. Shake until the iodine is all dissolved, dilute to the mark with water, and mix. This solution is approximately 0.05 N and is standardized against 0.05 N $Na_2S_2O_3$ to obtain its true normality.

Standard Sodium Thiosulfate Solution for SO_2.—Prepare and standardize as described above, except that 12.42 g. of pure crystallized $Na_2S_2O_3 \cdot 5H_2O$ are used or the 0.1 N solution may be diluted with an equal volume of cold CO_2-free water.

METHODS

WATER (NOTE 1)

Mix 100 g. of the paint in a 250-cc. flask with 75 cc. of toluene. Place the flask in an oil bath, connect with condenser, apply heat to the bath, and distil until about 50 cc. of distillate have been collected in a graduate. The temperature in the flask should be then about 105 to 110° C. The number of cubic centimeters of water collected under the toluene in the receiver is the percentage of water in the paint.

VOLATILE THINNER

Weigh accurately from 3 to 5 g. of the paint into a tared flat-bottomed dish about 8 cm. in diameter, spreading the paint over the bottom. Heat at 105 to 110° C. for one hour, cool, and weigh. Calculate the loss in weight as percentage of water and volatile thinner, subtract from this the percentage of water (1), and report the remainder as volatile thinner.

NATURE OF THE THINNER

Transfer about 150 g. of the paint to a 500-cc. flask fitted with a 2-hole cork stopper carrying a spray trap connected with a vertical condenser. Through the other hole in the stopper pass an influx tube for steam. (This tube should dip below the surface of the paint.) Heat the flask in an oil bath or an air bath at 100° C. and pass through it a current of steam; with the steam still passing through, raise the temperature of the bath to 130° C. Catch the distillate in a small separatory funnel; continue distillation until 300 cc. of water has been condensed. Portions of this water may be drawn from the cock of the separatory funnel from time to time, but care must be taken not to draw out any of the volatile thinner. Let the distillate stand until it separates into two layers, then draw off the water, and filter the volatile thinner through a dry filter paper into a dry flask. If the thinner is apparently turpentine, examine the distillate by the methods described in the Standard Methods of Sampling and Testing Turpentine (Serial Designation: D 233) of the American Society for Testing Materials.[1] If the thinner is a mixture of turpentine and mineral spirits, an approximate determination of the amount of turpentine may be made by the polymerization test specified for under turpentine. It should be noted that turpentine is slightly soluble in water (about 0.3 to 0.4 cc. per 100 cc. of water).

To test for benzol, add a few drops of the distillate to a small quantity of a mixture of concentrated HNO_3 and concentrated H_2SO_4, and heat cautiously. The characteristic odor of nitrobenzol will be noted if benzol is present.

If the thinner is apparently all mineral spirits, no further examination is necessary.

PERCENTAGE OF PIGMENT

Strain a portion of the well-mixed sample through a No. 80 sieve to remove any skins and weigh accurately about 15 g. of the strained paint in a weighed centrifuge tube. Add 20 to 30 cc. of "extraction mixture" (see "Reagents"), mix thoroughly with a glass rod, wash the rod with more of the extraction mixture, and add enough of the reagent to make a total of 60 cc. in the tube. Place the tube in the container of a centrifuge, surround the tube with water, and counterbalance the container of the opposite arm with a similar tube, or a tube with water. Whirl at a moderate speed until well settled. Decant the clear supernatant liquid, repeat the extraction twice with 40 cc. of extraction mixture and once with 40 cc. of ethyl ether. After drawing off the ether, set the tube in a beaker of water at about 80° C. or on top of a warm oven for 10 minutes, then in an oven at 105 to 110° C. for two hours. Cool, weigh, and calculate the percentage of pigment. Grind the pigment to a fine powder, pass through a No. 80 sieve to remove any skins, and preserve in a stoppered bottle.

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[1] 1927 Book of A.S.T.M. Standards, Part II.

PERCENTAGE OF NON-VOLATILE VEHICLE

Add together the percentages of water, of volatile thinner, and of pigment, and subtract the sum from 100. Report the remainder as non-volatile vehicle.

TESTING NON-VOLATILE VEHICLE

(a) *Preparation of fatty acids.*

To about 25 g. of the paint in a porcelain casserole, add 15 cc. of aqueous sodium hydroxide (see "Reagents") and 75 cc. of ethyl alcohol, mix and heat uncovered on a steam bath until all volatile thinner is driven off and saponification is complete. Add 100 cc. of water, boil, add H_2SO_4 (sp. gr. 1.2) (8 to 10 cc. in excess), boil, stir, and transfer to a separatory funnel to which some water has been previously added. Draw off as much as possible of the acid aqueous layer and any insoluble or precipitated matter, wash once with water, then add 50 cc. of water and 50 cc. of ethyl ether. Shake very gently with a whirling action to dissolve the fatty acids in the ether, but not so violently as to form an emulsion. Draw off the aqueous layer and wash the ether layer with one 15-cc. portion of water and then with 5 cc. portions of water until free from sulfuric acid. Then draw off the water layer completely. Transfer the ether solution to a dry flask and add 25 to 50 g. of anhydrous sodium sulfate. Stopper the flask and let stand with occasional shaking at a temperature below 25° C. until the water is completely removed from the ether solution, which will be shown by the solution becoming perfectly clear above the solid sodium sulfate. Decant this clear solution, if necessary, through a dry filter paper into a dry 100-cc. Erlenmeyer flask. Pass a rapid current of dry air (pass through a $CaCl_2$ tower) into the mouth of the Erlenmeyer flask and heat to a temperature below 75° C. on a dry hot plate until the ether is entirely driven off. It is important to follow all of the details, since ether generally contains alcohol, and after washing with water always contains water. It is very difficult to remove water and alcohol by evaporation from fatty acids, but the washing of the ether solution and subsequent drying with anhydrous sodium sulfate removes both water and alcohol. Ether, in the absence of water and alcohol, is easily removed from fatty acids by gentle heat.

If the pigment settles out rapidly in a sample of the paint on standing so that sufficient vehicle can be poured off; or, if sufficient vehicle is obtained by centrifuging the paint, it will be advantageous to saponify this separated vehicle and liberate and prepare the fatty acids as described.

The fatty acids prepared as above should be kept in a stoppered flask and examined at once.

(*b*) *Test for mineral oil and other unsaponifiable matter.*

Place 10 drops of the fatty acids Method (*a*), in a 50-cc. test tube, add 5 cc. of alcoholic soda (see "Reagents"), boil vigorously for five minutes, add 40 cc. of water, and mix; a clear solution indicates that not more than traces of unsaponifiable matter are present.

(*c*) *Iodine number of fatty acids* (Note 2).

Place a small quantity of the fatty acids Method (*a*), in a small weighing burette or beaker. Weigh accurately. Transfer by dropping about 0.15 g. (0.10 to 0.20 g.) into a 500-cc. bottle having a well ground glass stopper, or an Erlenmeyer flask having a specially flanged neck for the iodine test. Reweigh the burette or beaker and determine the amount of sample used. (If desired the sample may be weighed in a small wide-mouthed vial and the vial containing the weighed sample placed in the bottle or flask.) Add 10 cc. of chloroform. Whirl the bottle or flask to dissolve the sample. Add 10 cc. of chloroform to two empty bottles or flasks like that used for the sample. Add to each bottle or flask 25 cc. of the Wijs solution (see "Reagents") and let stand with occasional shaking for 1 hour in a dark place at a temperature of from 21 to 23° C. Add 10 cc. of the 15-per-cent potassium iodide solution and 100 cc. of water, and titrate with standard sodium thiosulfate solution (see "Reagents"), using starch as indictaor. The titrations on the two blank tests should agree within 0.1 cc. From the difference between the average of the blank titrations and the titration on the sample and the iodine value of the thiosulfate solution, calculate the iodine number of the sample tested. (Iodine number is centigrams of iodine to 1 g. of sample.)

(*d*) *Rosin.*

Liebermann-Storch Test.[1]—To about 1 g. of the fatty acids add 15 cc. of acetic anhydride and shake until solution is complete. Pour a few drops of this solution on a white porcelain plate (a crucible cover serves well) and add a drop of H_2SO_4 (sp. gr. 1.53). A fugitive violet color indicates rosin.

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[1] "Chemical Technology and Analysis of Oils, Fats and Waxes," by J. Lewkowitsch, Vol. I, p. 623 (1921).

Halphen-Hicks Test.[1]—Place about 1 g. of the fatty acids in a cavity of an ordinary porcelain color-reaction plate. Fill the cavity with a solution of one part by volume of phenol dissolved in two parts by volume of carbon tetrachloride. Stir the mixture. Fill another cavity of the porcelain plate with a solution of one part by volume of bromine and four parts by volume of carbon tetrachloride. Cover the whole plate with an inverted watch glass. If rosin is present the bromine fumes develop very soon an indigo blue color which persists for some time.

ANALYSIS OF PIGMENT

(*a*) *Qualitative Analysis.*

A complete qualitative analysis, following the well-established methods, should be made and the quantitative scheme modified as required. Add acetic acid slowly to the pigment until all carbonate is decomposed (noting whether any hydrogen sulfide is evolved); then add a large excess of acid ammonium acetate solution (see "Reagents"), boil, filter, and test the filtrate for metals other than lead and zinc (especially calcium and barium). The absence of calcium in this filtrate indicates that the extending pigments contain no calcium carbonate or calcium sulfate; the absence of barium indicates that the extending pigments contain no barium carbonate (Note 5). Wash the matter insoluble in acid ammonium acetate solution with another portion of this solution, and finally with hot water. This insoluble matter is dried, ignited, and tested for siliceous matter, barium sulfate, and titanium compounds. To test for the latter, place a small amount of the insoluble matter, or of the original sample (about 0.5 g.), in a 250-cc. Pyrex glass beaker; add 20 cc. of concentrated H_2SO_4 and 7 to 8 g. of ammonium sulfate. Mix well, and boil for a few minutes. A residue denotes the presence of silica or siliceous matter. Cool the solution, dilute with 100 cc. of water, heat to boiling, settle, filter, wash with hot 5-per-cent sulfuric acid until free from titanium. The residue may be tested for lead, barium, and silica. Add hydrogen peroxide to a small portion of the filtrate; a clear yellow-orange color indicates the presence of titanium. Boil another portion of the filtrate with metallic tin or zinc; a pale blue to violet coloration indicates titanium. Treat another portion (about 1 g.) of the pigment with 20 cc. of HCl (1:1) and note whether any H_2S is evolved; boil the solution for about 5 minutes, add about 25 cc. of hot water, filter, and wash with hot water. Render a small portion of the filtrate alkaline with NH_4OH, acidify with HCl, and add a little $BaCl_2$ solution; a white precipitate ($BaSO_4$) indicates the presence of a soluble sulfate. To another portion of the filtrate add a little H_2SO_4; a white precipitate indicates the presence of lead, soluble barium or both (some $CaSO_4$ may also separate); filter, wash to remove free acid, and treat the precipitate with a few drops of KI solution; the formation of yellow PbI_2 indicates the presence of lead. The white precipitate may also be treated with H_2S water; the formation of black PbS indicates the presence of lead. To another portion of the original filtrate add NH_4OH until alkaline, render slightly acid with acetic acid, heat to boiling, and add a little $K_2Cr_2O_7$ solution; a yellow or orange-yellow precipitate indicates the presence of lead, soluble barium or both. To another portion of the original filtrate add a few drops of $K_4Fe(CN)_6$ solution; a white precipitate with a blueish tinge indicates the presence of zinc. Pass into the remaining portion of the original filtrate a current of H_2S for 5 to 10 minutes, add an equal volume of water and pass H_2S into the solution for about 5 minutes; filter, wash with H_2S water; then digest the precipitate with ammonium polysulfide, filter, acidify the filtrate with HCl and warm; the presence of antimony is indicated by the separation of an orange colored precipitate. The filtrate from the H_2S precipitate may be tested for barium, calcium, and magnesium in the usual manner.

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[1] *Journal of Industrial and Engineering Chemistry*, Vol. 3, p. 86 (1911).

(*b*) *Quantitative Analysis.*

(1) *Single Pigments:*

If the sample is a single pigment, follow the method described in the Standard Methods of Routine Analysis of White Pigments (Serial Designation: D 34) of the American Society for Testing Materials[1] for the particular pigment in hand.

(2) *Mixed or Composite Pigments:*

Moisture (Note 3) (*Matter Volatile at 105–110° C.*).—Place 1 to 2 g. of the sample in a wide-mouth, short weighing tube provided with glass stopper. Heat with the stopper removed for 2 hours at a temperature between 105 and 110° C. Insert the stopper, cool, and weigh. Calculate the loss in weight as moisture (matter volatile at 105 to 110° C.).

Loss on Ignition.—Ignite 1 g. of the pigment in a porcelain crucible over a Meker burner to constant weight (Note 4).

Insoluble Matter.—Moisten 1 g. of the sample with a few drops of alcohol, cover, add 40 cc. of HCl (1:1), boil gently for 5 to 10 minutes. Wash off cover, evaporate to dryness, and heat at about 150° C. for one-half to one hour to dehydrate the residue. Moisten the residue with 4 cc. of concentrated HCl, allow to stand a few minutes, dilute with 100 cc. hot water, boil a few minutes, filter hot through paper, wash with hot water (till washings give no test for lead and chlorine). Ignite the paper and residue in a platinum or porcelain crucible, cool, and weigh total insoluble matter (Note 5). (The insoluble matter may be filtered off on a Gooch crucible, washed with hot water, dried at 105° C., cooled, and weighed; then ignited, cooled, and weighed, when it is desired to get the loss on ignition (combined water, organic matter, etc.) of same, or the insoluble matter is not to be further examined.) If the sample contains titanium pigment, practically all of the TiO_2 will be found in the insoluble matter along with $BaSO_4$ and siliceous matter. The TiO_2 may be determined in the insoluble matter or in a separate portion of the original sample by the method described in the Standard Methods of Routine Analysis of Titanium Pigments (Serial Designation: D 186) of the American Society for Testing Materials.[1] To determine $BaSO_4$, mix the ignited insoluble matter with about 10 times its weight of anhydrous sodium carbonate (grinding the mixture in an agate mortar if necessary), and fuse the mixture in a covered platinum crucible, heating about one hour. Let cool, place crucible and cover in a 250-cc. beaker, add about 100 cc. of water, and heat until the melt is disintegrated. Filter on paper (leaving crucible and cover in beaker) and wash the beaker and filter thoroughly with hot water to remove soluble sulfates. Place the beaker containing the crucible and cover under the funnel, pierce the filter with a glass rod, and wash the residue into the beaker by means of a jet of hot water. Wash the paper with hot dilute HCl (1:1) and then with hot water. Remove crucible and cover, washing them with a jet of hot water and removing any adhering precipitate. Add cautiously 20 cc. of concentrated H_2SO_4 and evaporate until fumes of H_2SO_4 are evolved and the precipitated matter is dissolved. *Cool*, add cautiously, with stirring, about 100 cc. of water, and boil a few minutes. Let the precipitate settle, filter on a weighed Gooch crucible, wash with hot water, ignite, cool, and weigh as $BaSO_4$. Subtract the sum of the percentages of $BaSO_4$ and TiO_2 from the percentage of total insoluble matter and report the result as the percentage of insoluble siliceous matter (Note 6).

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[1] 1927 Book of A.S.T.M. Standards, Part II.

If it is desired to examine the siliceous matter, unite the filtrates from the Na_2CO_3 fusion and the $BaSO_4$ precipitate, acidify with HCl, evaporate to dryness, and proceed as in a silicate analysis, taking cognizance of any TiO_2 that may be found, if titanium pigment were originally present.

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[1] 1927 Book of A.S.T.M. Standards, Part II.

Total Lead (Antimony).—Unite the filtrate and washings (total volume 150 to 200 cc.) from the total insoluble matter, pass H_2S into the solution until it is saturated, add an equal volume of water, and again saturate with H_2S. Filter, wash with water containing a little hydrogen sulfide, dissolve in hot HNO_3 (1:3), washing the paper with hot water; add 10 to 20 cc. of H_2SO_4 (1:1), evaporate until copious fumes of sulfuric acid are evolved; cool, add about 75 cc. of water, and then about 75 cc. of 95-per-cent ethyl alcohol. Stir, let settle, filter on a Gooch crucible, wash with dilute alcohol, dry in an oven at 105 to 110° C.; or, ignite gently in a radiator[1] or muffle, cool, and weigh as $PbSO_4$. Calculate to PbO (Note 7).

If the pigment contains antimony, filter and wash the sulfide precipitate as above; then wash the precipitate with a fine jet of H_2O from the paper into a porcelain dish or casserole, add 25 cc. of ammonium polysulfide (see "Reagents"), cover the vessel, and warm the mixture at 40 to 60° C. for 10 to 15 minutes with frequent stirring. Wash off cover, filter through the paper used in the first case, and wash with 2 to 3-per-cent Na_2S or $(NH_4)_2S$ solution. Discard the filtrate. Dissolve the residue in hot dilute HNO_3 (1:3), and determine the lead as $PbSO_4$, as described above. Or, the original sulfide precipitate may be discarded and the lead determined on a separate portion of the pigment as follows: To 1 g. of the sample in a covered beaker, add 40 cc. of HCl (1:1) and boil gently for 5 to 10 minutes. Wash off cover and evaporate to dryness. Moisten the residue with a few drops of HCl, add about 50 cc. of hot water, boil a few minutes, filter hot through paper, and wash with hot water until washings give no test for lead. (If the sample contains no insoluble matter, the filtration is omitted.) To the filtrate add 20 cc. of H_2SO_4 (sp. gr. 1.84) and evaporate until dense white fumes of H_2SO_4 are copiously evolved. Allow to cool, but not below 60° C., and then add slowly 50 cc. of water while the solution is agitated. Heat to boiling for several minutes in order to insure complete solution of antimony sulfate. Allow the $PbSO_4$ to settle out until the supernatant liquid is clear, not letting the temperature fall below 60° C. If the liquid does not clear quickly it must be heated longer. When clear, pour the solution through a weighed porcelain Gooch crucible with asbestos mat, decanting the solution as completely as possible without allowing more than a very small amount of $PbSO_4$ to go over into the crucible. Now add 10 cc. more of H_2SO_4 (sp. gr. 1.84) to the $PbSO_4$ in the original beaker, and boil for several minutes. Cool, add slowly 30 cc. of water, and again heat to boiling for a few minutes; allow the solution to cool to about

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[1] *U. S. Geological Survey Bulletin 700*, p. 33 (1919).

60° C. and completely transfer the $PbSO_4$ to the Gooch crucible. Wash with "lead acid" (see "Reagents") to remove soluble sulfates and finally wash free of acid with dilute alcohol (equal parts of ethyl alcohol or denatured alcohol and water). Dry in an oven at 105 to 110° C., or, ignite gently in a radiator or muffle. Calculate to PbO. Or, determine as chromate as described below.

If soluble compounds of barium or calcium are present, $BaSO_4$ and $CaSO_4$ will be included with the $PbSO_4$. If soluble SiO_2 is present, it will also be included with the $PbSO_4$. In such cases, the $PbSO_4$ precipitate after washing with dilute alcohol may be dissolved in acid ammonium acetate (see "Reagents") and the lead determined as $PbCrO_4$, as described below. For ordinary work, the amount of $BaSO_4$ dissolved by the acetate treatment may be disregarded.

If the pigment contains no soluble antimony, barium, or calcium compounds, the lead may be determined directly on the original pigment, as follows: To 1 g. of the sample in a covered beaker, add 25 cc. of HNO_3 (1:1), and boil gently a few minutes. Wash off cover, evaporate to dryness on a steam bath, moisten with HNO_3, add hot water, and heat a few minutes. Filter and wash with hot water until washings are lead-free. Add 10 to 20 cc. of H_2SO_4 (1:1) to the clear solution, evaporate and determine lead as $PbSO_4$, as above described.

In the absence of soluble compounds of antimony, iron, aluminum, and barium, the following procedure may be used: Treat 1 g. of the original pigment with 25 cc. of HNO_3 (1:1) and proceed as above. To the clear solution, diluted to 200 cc. add NH_4OH in slight excess, acidify with acetic acid, and add 4 to 6 cc. more of this acid; heat to boiling and add 10 to 15 cc. of a 10-per-cent solution of $K_2Cr_2O_7$. Heat until the yellow precipitate assumes an orange color, let settle and filter on a weighed Gooch crucible, wash by decantation until the washings are colorless, finally transferring all of the precipitate. Then wash with 95-per-cent ethyl alcohol and then with ether; dry to constant weight at 110° C., cool, and weigh $PbCrO_4$. Calculate to PbO.

Antimony Oxide.—Transfer 0.3 g. of a straight antimony oxide pigment, or 0.5 g. of a mixed pigment, to a 500-cc. Pyrex Erlenmeyer flask, add 15 cc. of water and 25 cc. of concentrated HCl (sp. gr. 1.19). Cover with a watch glass, warm on the steam bath 10 to 15 minutes to dissolve the antimony oxide, wash off cover, add 250 cc. of water, and 15 cc. of concentrated H_2SO_4 (sp. gr. 1.84). Boil 2 minutes, cool to 10 to 15° C., and titrate to a faint pink tint with 0.1 N $KMnO_4$ solution (see "Reagents"). Calculate to Sb_2O_3.

The above procedure gives only the antimony in the *ous* condition. The following method gives the total antimony (*ous* and *ic* forms):

Transfer 0.3 g. of a straight antimony oxide pigment, or 0.5 g. of a mixed pigment, to a 500-cc. Pyrex Erlenmeyer flask, add 15 cc. of H_2SO_4 (sp. gr. 1.84), 10 g. of K_2SO_4, and a 9-cm. filter paper (to furnish carbon to act as a reducing agent). Place a funnel in the neck of the flask, and heat until the solution becomes colorless. Cool, wash off the funnel, dilute to 250 cc. with water, add 20 cc. of concentrated HCl, and boil 2 minutes; cool to 10 to 15° C., and titrate to a faint pink tint with 0.1 *N* $KMnO_4$ solution (Note 8).

Antimony Oxide (in the presence of appreciable amounts of iron).—Treat 1 g. of the mixed pigment, or 0.3 g. of a straight antimony oxide pigment, in a covered 250-cc. beaker with 5 cc. of water and 20 cc. of HCl (sp. gr. 1.19); heat on the steam bath for 15 minutes, cool, wash off cover, add 3 g. of tartaric acid and 100 cc. of hot water, and digest a few minutes. Filter, catching the filtrate in a 500-cc. Pyrex Erlenmeyer flask; wash thoroughly with hot water, dilute to 300 cc. with hot water, and pass in H_2S until the precipitation is complete. (If the sample contains no insoluble matter, disolve directly in a 500-cc. Pyrex Erlenmeyer flask, add tartaric acid, dilute, and pass in H_2S.) Filter, wash with water containing H_2S until free from HCl, return paper and precipitate to the Erlenmeyer flask, add 15 cc. of H_2SO_4 (sp. gr. 1.84) and 10 g. of K_2SO_4, place a funnel in the neck of the flask, and heat until the solution is colorless. Cool, wash off the funnel, dilute to about 250 cc. with water, add 20 cc. of HCl (sp. gr. 1.19), boil for 2 or 3 minutes, cool to about 10° C., and titrate to a faint pink tint with 0.1 *N* $KMnO_4$ solution (see "Reagents"). Calculate the total antimony to Sb_2O_3 (Note 9).

Soluble Barium.—Boil the combined filtrate and washings, reduced in volume by evaporation if need be, from the PbS precipitate (Total Lead) to expel H_2S. Add a slight excess of H_2SO_4 (1:4) over the amount required to precipitate the barium, heat to boiling, let stand on a steam bath about one hour, filter on a weighed Gooch crucible, wash with hot water, dry, ignite, cool, and weigh $BaSO_4$ (Notes 5 and 10). Calculate to BaO.

Alumina (Fe_2O_3, TiO_2, P_2O_5).—Boil the filtrate from the PbS to expel H_2S, add a few drops of HNO_3, and continue the boiling a few minutes to oxidize any iron that may be present. In case soluble barium was present, use the filtrate from that determination. To the solution containing at least 5 g. of NH_4Cl per 200 cc. of solution, or an equivalent amount of HCl, add a few drops of methyl red (0.2-per-cent alcoholic solution) and heat just to boiling. Carefully add dilute NH_4OH drop by drop until the color of the solution changes to a distinct yellow. Boil the solution for one to two minutes and filter at once. Wash the precipitate thoroughly with hot 2-per-cent NH_4Cl solution (Note 11). Ignite the precipitate, cool, and weigh as Al_2O_3 (Note 12).

Total Zinc.—(*a*) To the combined filtrate and washings from the alumina precipitate, add sufficient NH_4Cl to give 5 g. per 100 cc. of solution, and then add 1 g. of ammonium acetate.[1]

Render slightly acid with acetic acid and pass in a current of H_2S to saturation. Allow the precipitate to settle completely, filter on paper, and wash with a 2-per-cent solution of acetic acid saturated with H_2S. Transfer the precipitate and filter to the vessel in which the precipitation was effected, add 30 cc. of water and 10 cc. of concentrated HCl, heat until all zinc is in solution, add 200 cc. of water and a small piece of litmus paper; add strong NH_4OH until slightly alkaline, render just acid with HCl, then add 3 cc. of concentrated HCl, heat nearly to boiling, and titrate with standard potassium ferrocyanide solution as in standardizing that solution (see "Reagents").

(*b*) Zinc may be determined directly on the original sample as follows (Note 13): Weigh accurately about 1 g. (or an amount that will give a burette reading approximately equal to that obtained in the standardization) of the pigment, transfer to a 400-cc. beaker, add 30 cc. of HCl (1:2), boil a few minutes, add 200 cc. of water and a small piece of litmus paper; add strong NH_4OH until slightly alkaline, render just acid with HCl, then add 3 cc. of concentrated HCl, heat nearly to boiling, and titrate with standard $K_4Fe(CN)_6$ solution as in standardizing that solution (see "Reagents").

(*c*) When iron is present, total zinc may be determined directly on the original sample as follows (Note 13): Weigh accurately about 1 g. (or an amount that will give a burette reading approximately equal to that obtained in the standardization) of the pigment, transfer to a 250-cc. beaker, moisten with alcohol, add 30 cc. of HCl (1:2), boil for 2 or 3 minutes, and add about 100 cc. of water. Add about 2 g. of NH_4Cl, make slightly alkaline with NH_4OH, heat to boiling, let settle on steam bath, filter into a 400-cc. beaker and wash the residue once with hot water. Remove the 400-cc. beaker and pour dilute HCl on the residue, catching the filtrate therefrom in the 250-cc. beaker, wash a few times with hot water. Add to this filtrate 1 g. of NH_4Cl and make slightly alkaline with NH_4OH, boil, let settle, filter on paper used for first filtration, and wash thoroughly with hot water, catching the filtrate and washings in the 400-cc. beaker containing the first filtrate. Add a small piece of litmus paper, acidify with HCl, add 3 cc. of concentrated HCl, heat nearly to boiling, and titrate with standard $K_4Fe(CN)_6$ as above.

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[1] F. A. Gooch, "Representative Procedures in Quantitative Chemical Analysis," 1st Ed., p. 107.

(*d*) With pigments containing ZnO and ZnS the ZnO may be determined as follows: Weigh accurately 2.5 g. of the pigment, transfer to a 250-cc. graduated flask, moisten with a few drops of alcohol, add about 200 cc. of 2 to 3-per-cent acetic acid, shake vigorously and let stand for 30 minutes at room temperature, shaking once every 5 minutes. Then let stand at room temperature at least 5 hours, preferably overnight. Fill to the mark with 2 to 3-per-cent acetic acid, mix, filter through a dry paper, discard the first 25 cc. and transfer 100 cc. of the filtrate (corresponding to 1 g.) to a 400-cc. beaker. To the clear solution add 30 cc. of HCl (1:2), 100 cc. of H_2O, and a small piece of litmus paper; add strong NH_4OH until slightly alkaline, render just acid with HCl, then add 3 cc. of concentrated HCl, heat nearly to boiling, and titrate with $K_4Fe(CN)_6$ as above. Calculate the percentage of ZnO (any $ZnCO_3$ or $ZnSO_4$ is included in the ZnO). Subtract this result from the percentage of total Zn as ZnO, and calculate the difference to ZnS.

Soluble Calcium.—Heat the united filtrate and washings, reduced in volume if need be, from the ZnS precipitate, to boiling, add 1 cc. of NH_4OH and an excess of a hot saturated ammonium oxalate solution. Continue the boiling until the precipitate becomes granular; let stand about one hour, filter, and wash with hot water. Ignite, cool, and weigh as CaO (Notes 5, 14, 15); or, place the beaker in which the precipitation was made under the funnel, pierce the apex of the filter with a stirring rod and wash the precipitate into the beaker with hot water, pour warm dilute H_2SO_4 (1:4) through the paper and wash a few times. Add about 30 cc. of dilute H_2SO_4 (1:4), dilute to about 250 cc., heat to 90° C. and titrate at once with standard (0.1 *N*) $KMnO_4$ solution (the temperature of the solution should not be below 60° C. when the end point is reached. See "Reagents"). Calculate to CaO (Notes 5, 14, 15). (The Fe value of $KMnO_4 \times 0.502 =$ CaO value.)

Soluble Magnesium.—Acidify the filtrate from the calcium precipitate with HCl, add 10 cc. of a saturated solution of $Na(NH_4)HPO_4$ and NH_4OH drop by drop, with constant stirring. When the crystallin $(NH_4)MgPO_4$ has formed, add 5 cc. excess of NH_4OH. Allow the solution to stand in a cool place for not less than 4 hours, preferably overnight (Note 16); filter and wash with water containing 2.5 per cent of NH_3. Dissolve the precipitate in a small quantity of hot dilute HCl, dilute the solution to about 100 cc. with water, add 1 cc. of a saturated solution of $Na(NH_4)HPO_4$ and NH_4OH drop by drop, with constant stirring, until the precipitate is again formed as described, and then add 5 cc. excess of NH_4OH. Let the precipitate stand in a cool place for not less than 2 hours, filter on a Gooch crucible, wash with water containing 2.5 per cent of NH_3, ignite, cool, and weigh as $Mg_2P_2O_7$ (Note 17). Calculate to MgO.

Carbon Dioxide.—Determine by evolution with dilute acid and absorption in soda lime or KOH solution. The method given in U. S. Geological Survey Bulletin 700, p. 218, shows a convenient apparatus for carrying out this determination. Use from 1 to 2 g. of the pigment, depending upon the probable CO_2 content, following the method for the determination of carbon dioxide in lime described in the Tentative Methods of Chemical Analysis of Limestone, Quicklime and Hydrated Lime (Serial Designation: C 25 - 27 T) of the American Society for Testing Materials[1] (Note 18).

Total Soluble Sulfur Compounds (Note 5).—Treat 1 g. of the pigment in a 400-cc. beaker with 10 cc. of H_2O, 10 cc. of strong HCl saturated with bromine, and 5 g. of NH_4Cl, digest (covered) on a steam bath for 5 minutes, dilute with hot water to about 200 cc., boil for 5 minutes, filter to separate any insoluble matter, and wash thoroughly with hot water. Nearly neutralize the clear solution in a covered beaker with NaOH solution, complete the neutralization with dry Na_2CO_3 and add about 2 g. more of this reagent. Boil 10 to 15 minutes, wash off cover, let settle, filter, and wash with hot water. Re-dissolve the precipitate in HCl (1:1), reprecipitate with Na_2CO_3 as above, filter, and wash thoroughly with hot water. Acidify the united filtrates with HCl, adding about 1 cc. in excess. Boil to expel bromine, and to the clear boiling solution add slowly with stirring an excess of a 10-per-cent $BaCl_2$ solution. Let stand on a steam bath for at least 1 hour, filter on a weighed Gooch crucible, wash thoroughly with boiling water, dry, ignite at a dull red heat, cool, and weigh as $BaSO_4$. This will include soluble sulfates, SO_3 formed from SO_2 and the SO_3 that is formed from sulfide sulfur (Note 10).

Soluble Sulfate (Note 5).—Treat 1 g. of the pigment with 10 cc. of H_2O and 10 cc. of concentrated HCl and 5 g. of NH_4Cl. Boil until H_2S is expelled, adding more HCl (1:1) if necessary; dilute with hot water to about 200 cc., boil for 5 minutes, filter to separate any insoluble matter, and wash thoroughly with hot water. Nearly neutralize the clear solution with NaOH solution and make a double precipitation with Na_2CO_3, as in preceding method, finally weighing as $BaSO_4$, as described above (Note 10).

Sulfide Sulfur[2] (Note 19).—Place 0.5 to 1 g. of the pigment in a flask with about 10 g. of "feathered" or mossy zinc, add 50 cc. of water;

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[1] See p. 776.

[2] Evolution Method of W. G. Scott, "White Paints and Painting Materials," p. 257; see also Blair, "The Chemical Analysis of Iron."

insert a stopper carrying a separatory funnel and an exit tube. Run in 50 cc. of concentrated HCl from the funnel, having previously connected the exit tube to two absorption flasks in series; the first flask contains 100 cc. of alkaline lead-nitrate solution (see "Reagents"), the second flask, 50 cc. of the same solution as a safety device. After all of the acid has run into the evolution flask, heat slowly, finally boiling until the first appearance of steam in the first absorption flask. Disconnect, let the lead sulfide settle, filter, wash with cold water, then with hot water till neutral to litmus paper and washings give no test for lead. Dissolve the PbS precipitate in hot, dilute HNO_3, and determine the lead as $PbSO_4$. Calculate to S. For very rapid work, the evolved H_2S may be absorbed in an ammoniacal $CdCl_2$ or $ZnSO_4$ solution (see "Reagents") contained in 2 flasks connected in series, the contents of the absorption flasks washed into a vessel with cold water and diluted to about one liter, acidified with concentrated HCl and titrated with standard potassium iodate solution (see "Reagents"), using starch indicator (see "Reagents").

Sulfur Dioxide (Note 20).—Transfer 10 g. of the pigment to a suitable flask, insert a stopper fitted with a separatory funnel and a spray trap delivery tube (Note 21), and attach the latter to a condenser. Place about 150 cc. of HCl (1:3) in the funnel, the stopcock being closed (Note 22), connect the other end of the condenser with a delivery tube which passes through a 2-hole stopper and extends nearly to the bottom of an absorption flask; through the other hole of the stopper connect a tube or flask to serve as a safety device. Place 25 cc. of 0.05 *N* iodine solution (see "Reagents") in the absorption flask (dilute with water if need be) and 20 cc. of 10-per-cent KI solution in the safety tube; fit stopper in the absorption flask. Open the stopcock and allow the acid to slowly enter the flask. Before all of the acid is admitted, air (washed with NaOH solution) is forced through the top of the separatory funnel (about 2 bubbles per second in the KI solution). Boil the solution 3 minutes with the air passing through, then remove the source of heat and pass air through for 30 minutes. Disconnect the absorption vessels, wash the KI solution into the iodine solution, and titrate at once with 0.05 *N* $Na_2S_2O_3$ solution, using starch indicator. Run a blank determination in exactly the same manner except for the omission of the pigment. Subtract this figure from the previous one and calculate the final result to SO_2 (1 cc. 0.05 *N* I = 0.0016 g. SO_2).

Matter Soluble in Water.—Transfer 2.5 g. of the pigment to a graduated 250-cc. flask, add 100 cc. of water, boil for 5 minutes, cool, fill to mark with water, mix, and allow to settle. Pour the supernatant liquid through a dry filter paper and discard the first 20 cc. Then evaporate 100 cc. of the clear filtrate to dryness in a weighed dish, heat for one hour at 105 to 110° C., cool, and weigh. Calculate the percentage. The nature of this may be determined by further examination, as the percentages of SO_3 and CaO may be indicative.

NOTES

1. A convenient apparatus for this determination is shown in Fig. 1 (*b*) of the Standard Method of Test for Water in Petroleum Products and Other Bituminous Materials (Serial Designation: D 95) of the American Society for Testing Materials.[1]

2. If appreciable amounts of rosin or of unsaponifiable matter are found to be absent in the vehicle of a paint, the iodine number of the fatty acids gives the best indication (though not proof) of the presence of linseed oil. An iodine number of less than 175 (Wijs) for the fatty acids is an indication that the nonvolatile vehicle was not pure linseed oil.

3. On an extracted and dried pigment, this determination is of little value. If the original paint contained gypsum, a part of the combined H_2O of the latter will be driven off in the drying of the extracted pigment and in the "moisture" determination.

4. This determination may serve as a rough or approximate check in many cases on the CO_2, H_2O, etc.

5. If the original sample contained $BaCO_3$ and $PbSO_4$, $CaSO_4$ or other soluble sulfate, the soluble Ba will form with the soluble sulfate a precipitate of $BaSO_4$ which will be determined as "insoluble matter." If the sample contained $SrSO_4$ or $SrCO_3$, some $SrSO_4$ may be counted as $BaSO_4$, some Sr will count as soluble barium, and some may be counted as CaO. This element is not separated, as it probably will not be encountered, or will be present as an impurity in the Ba and Ca compounds.

6. Any soluble Al_2O_3 (Fe_2O_3) and in most cases MgO, and sometimes some CaO, come from the siliceous pigment used. MgO generally denoted the presence of asbestine.

7. It is not possible to determine the amount of basic lead carbonate and lead sulfate when carbonates or soluble sulfates of other metals, such as calcium, are present. Also neither basic lead carbonate nor basic lead sulfate are definite compounds.

8. If the digestion with H_2SO_4 and K_2SO_4 (plus filter paper) is continued after the solution becomes colorless, some of the antimony may be oxidized from the *ous* to the *ic* condition. In such cases, cool, wash off the funnel, dilute to 100 cc. with water, add 1 to 2 g. of Na_2SO_3 and boil until all of the SO_2 is expelled. This is shown when no blue color is obtained with starch-iodate paper (see "Reagents"); the volume will be reduced about one-half. Dilute to 250 cc. with water, add 20 cc. of HCl (sp. gr. 1.19), and boil 2 minutes; cool to 10 to 15° C., and titrate to a faint pink tint with 0.1 *N* $KMnO_4$ solution. Calculate total Sb to Sb_2O_3. Subtract the Sb_2O_3 found by the procedure given in the first paragraph under Antimony Oxide from the total Sb_2O_3 and calculate the residual Sb_2O_3 to Sb_2O_5.

9. If the digestion with H_2SO_4 and K_2SO_4 (plus filter paper) is continued after the solution becomes colorless, some of the antimony may be oxidized from the *ous* to the *ic* condition. In such cases, cool, wash off the funnel, dilute to 100 cc. with

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[1] 1927 Book of A.S.T.M. Standards, Part II.

water, add 1 to 2 g. of Na_2SO_3 and boil until all of the SO_2 is expelled. This is shown when no blue color is obtained with starch-iodate paper (see "Reagents"); the volume will be reduced about one-half. Dilute to 250 cc. with water, add 20 cc. of HCl (sp. gr. 1.19), and boil 2 minutes; cool to 10 to 15° C., and titrate to a faint pink tint with 0.1 *N* $KMnO_4$ solution.

10. This will include any $BaSO_4$ that may have been dissolved as such. The weighed precipitate should be tested for $CaSO_4$, and if present, it should be removed by treating with hot dilute HCl, filtering, washing, igniting, and again weighing.

11. For very accurate work, or when the precipitate is large, the precipitate should be dissolved in HCl (1:1) and the precipitation repeated.

12. This precipitate may also contain Fe_2O_3, TiO_2, and P_2O_5.

13. If the sample contains antimony, it should be precipitated by H_2S in the hot acid solution, filtered off, washed, and the filtrate neutralized, etc., for zinc. The H_2S precipitate may also contain PbS. If no sulfide separation is made, any cadmium present will be counted as zinc.

14. Care must be exercised in this washing, as 1000 cc. of boiling water will dissolve over 0.01 g. of CaC_2O_4.

15. For more accurate work, the CaC_2O_4 precipitate should be ignited, cooled, cautiously moistened with water, redissolved in HCl and the solution diluted to 100 cc. Then NH_4OH should be added in slight excess, the liquid boiled, and filtered and washed if a precipitate appears. Then reprecipitate the Ca with NH_4OH and $(NH_4)_2C_2O_4$ as above, filter, wash, ignite, cool, and weigh; or, titrate as described.

16. The less the amount of magnesium present, the longer the precipitate must be allowed to settle.

17. If the sample contained manganese, it will be caught in large part with the $Mg_2P_2O_7$. If desired, Mn may be determined by dissolving the $Mg_2P_2O_7$ in HNO_3 and applying the bismuthate method.

18. If the sample is high in sulfide, *e. g.*, contains a high percentage of lithopone, grind 1 to 2 g. of the pigment with dry $K_2Cr_2O_7$, transfer to the evolution flask, add 50 cc. of water, and run in H_2SO_4 (1:1) from the separatory funnel. Or, place at the front of the purifying and drying train a tube containing acidified $CuSO_4$ solution, $KMnO_4$ solution, or CrO_3 solution.

19. The percentage of sulfide sulfur can be calculated from the percentages of total zinc and zinc soluble in 2 to 3 per cent acetic acid, assuming the sulfide to be ZnS. See Method (*d*) under determination of zinc.

20. This method is not applicable in the presence of sulfides decomposable under the conditions given.

21. A Knorr CO_2 apparatus is very convenient. In this case, the vertical condenser may be connected with an absorption tower containing the iodine solution, followed by the KI solution in a suitable tube.

22. To minimize, if not eliminate, any possible oxidation by the air, add about 1 g. (in one piece) of $NaHCO_3$ to the evolution flask, then add the acid directly to the flask, omitting the separatory funnel and the current of air. Boil the solution until about 50 cc. of distillate has passed over.

CALCULATIONS

The calculation of the component pigments of a mixed or combination pigment may be a somewhat difficult matter. Certain assumptions must be made, depending upon the complexity of the mixed pigment, as to the composition or formulas of component pigments and as to the manner in which the acidic and basic radicles are combined. Add any Al_2O_3 (Fe_2O_3) found in the soluble portion to the siliceous matter and report the sum as "Insoluble siliceous matter," unless the soluble Al is high; in this case, an aluminate is probably present, and the Al_2O_3 should be reported as Al_2O_3. If a small amount of soluble Mg is found, it should also be added to the siliceous matter. If the soluble Mg is high, the presence of $MgCO_3$ is indicated, and the MgO is calculated to $MgCO_3$ as pointed out below. The insoluble siliceous matter reported should be based on the weight obtained on drying the total insoluble matter at 105° C. if the combined H_2O contained therein is to be considered.

In the absence of ZnS or TiO_2, report $BaSO_4$ as $BaSO_4$. If ZnS is present, calculate the $BaSO_4$ equivalent by multiplying by 2.85; report sum of $ZnS+BaSO_4$ as "lithopone." If TiO_2 is present, calculate the $BaSO_4$ equivalent by multiplying by 3.17; report sum of TiO_2+BaSO_4 as "titanium pigment." Report residual $BaSO_4$ as $BaSO_4$. If TiO_2 is present and $BaSO_4$ is absent or is present in a smaller amount than would be indicated by the above factor, then report TiO_2 as TiO_2, and $BaSO_4$ as $BaSO_4$. If $CaCO_3$, $CaSO_4$, $BaCO_3$, and $MgCO_3$ are absent calculate CO_2 to basic carbonate white lead, $(PbCO_3)_2 \cdot Pb(OH)_2$, and soluble SO_3 to $PbSO_4$. Any excess of Pb is calculated to PbO, added to the $PbSO_4$, and the sum reported as basic lead sulfate; or, multiply the sum of $PbSO_4+PbO$ by 0.058 to obtain the ZnO; add this result to the $PbSO_4+PbO$ and report as basic sulfate white lead. (The ZnO factor is based on the assumption that the average composition of commercial basic sulfate white lead is: 78.5 per cent $PbSO_4$, 16.0 per cent PbO, and 5.5 per cent ZnO.) Lead oxide (PbO) should not be reported except in the presence of $PbSO_4$; unless the entire analysis is reported in the elementary or oxide form.

If the sample contains CO_2 but no soluble SO_3, calculate total Pb to basic carbonate white lead, $(PbCO_3)_2 \cdot Pb(OH)_2$; calculate residual CO_2 to $CaCO_3$, then to $BaCO_3$ and $MgCO_3$ if soluble Ba and Mg should be present in sufficient amounts to indicate the presence of these carbonates. The CO_2 result will be an index of this. A small amount of residual CaO is probably from the sliceous matter and should be added to the insoluble siliceous matter.

A small amount of soluble Ba may be from the $CaCO_3$ used or may be due to the solubility of $BaSO_4$ if this compound is present in the original pigment. This Ba may be calculated to $BaSO_4$ and added to the $BaSO_4$ found in the insoluble matter.

If the sample contains soluble SO_3 but no CO_2, calculate CaO to

$CaSO_4$ or $CaSO_4 \cdot 2H_2O$; residual SO_3 to $PbSO_4$; add residual PbO to. $PbSO_4$ and report sum as basic lead sulfate; or, multiply $PbSO_4 +$ PbO by 0.058 and add the result to the $PbSO_4 + PbO$, and report the total as basic sulfate white lead.

If the sample contains $CaCO_3$ ($MgCO_3$, $BaCO_3$) and also basic sulfate white lead, or $CaSO_4$ and basic carbonate white lead; or a mixture of these; it is not possible to determine or calculate the amount of $PbCO_3$ or $PbSO_4$ with any degree of certainty (Notes 3 and 5). The presence of appreciable amounts of CaO and SO_3 in the water-soluble matter indicates the probable presence of $CaSO_4$ in the original pigment. The following arbitrary calculations may be made; calculate water-soluble SO_3 to $CaSO_4$ or $CaSO_4 \cdot 2H_2O$, subtract this SO_3 from total soluble SO_3 and calculate the remainder to $PbSO_4$; calculate residual CaO to $CaCO_3$, and then residual CO_2 to $(PbCO_3)_2 \cdot Pb(OH)_2$. If there is an excess of CO_2, calculate to $MgCO_3$ or $BaCO_3$, if the amounts of soluble Mg and Ba indicate the probable presence of these carbonates. Add residual PbO to $PbSO_4$ and calculate, as above, to basic sulfate white lead. The procedure followed by the Federal Specifications Board should be noted.[1]

Report total antimony as Sb_2O_3.

Calculate sulfide sulfur to ZnS, subtract the Zn equivalent to the S from the total Zn, then subtract the Zn required for the basic sulfate white lead, and report the remainder as ZnO.

Report moisture, loss on ignition, SO_2, and matter soluble in water directly.

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[1] Federal Specifications Board Specification No. 10 for "White Paint and Tinted Paints Made on a White Base, Semipaste and Ready Mixed"; Bureau of Standards *Circular No. 89*, 2d Ed., p. 2: "The total lead dissolved by dilute acetic acid and hot acid, ammonium acetate, weighed as lead sulfate, and this weight multiplied by the factor 0.883 shall be considered white lead. (It is not possible to determine the amount of lead carbonate and lead sulfate when carbonates or sulfates of other metals, such as calcium, are present. Also neither basic lead carbonate nor basic lead sulfate are definite compounds. The factor to convert $PbSO_4$ to $(PbCO_3)_2Pb(OH)_2$ is 0.854, to convert $PbSO_4$ to $PbSO_4 \cdot PbO$ is 0.868, and to convert $PbSO_4$ to $(PbSO_4)_2 \cdot PbO$ is 0.913. The arbitrary factor used under this specification is the mean of the largest and smallest of these three factors.)"

TENTATIVE METHOD OF TEST
FOR
DETERMINATION OF TOLUOL INSOLUBLE MATTER IN ROSIN
(CHIEFLY SAND, CHIPS, DIRT AND BARK)[1]

Serial Designation: D 269 - 27 T

This is a **Tentative Standard,** published for the purpose of eliciting criticism and suggestions, and as such is subject to annual revision.

Issued, 1927.

Treatment of Sample.

1. (*a*) If the sample is less than 200 g., immediately before the determination is made, powder it to pass a No. 10 sieve, mix thoroughly, and place in a wide-mouth bottle which is completely filled thereby.

(*b*) If the sample is more than 200 g., crush it to pass a ½-in. sieve, mix, quarter down to about 200 g., and treat as described in Paragraph (*a*).

Procedure.

2. Place 50 g. of the freshly-powdered sample in a 300-cc. beaker, add 150 cc. of toluol, free from water and non-volatile residue, and dissolve the sample with the aid of heat and occasional shaking. When solution is apparently complete (no particles of rosin visible) filter at once through a 25-cc. porcelain Gooch crucible which has been previously prepared with a mat of pure well-washed asbestos (such as is used for the determination of barium sulfate) and which has been finally washed thoroughly with the solvent used, dry in a boiling-water oven for 30 minutes, cool in a desiccator, and weigh. If the rosin filtrate is not clear return it through the Gooch crucible until clear, finally washing the residue and the outside of the crucible free from rosin with additional hot solvent. Dry the crucible and contents to constant weight at 105 to 110° C. in a boiling-water oven (one hour usually suffices), cool in a desiccator, weigh, and calculate the percentage of toluol insoluble.

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[1] Criticisms of this Tentative Method are solicited and should be directed to Mr. C. F. Speh, Secretary of Committee D-17 on Naval Stores, Pine Institute of America, Barnett National Bank Building, Jacksonville, Fla.

TENTATIVE METHODS OF SAMPLING PETROLEUM AND PETROLEUM PRODUCTS[1]

Serial Designation: D 270 – 27 T

This is a **Tentative Standard,** published for the purpose of eliciting criticism and suggestions, and as such is subject to annual revision.

ISSUED, 1927.

PURPOSE AND SCOPE

Purpose. 1. Samples are taken for the purpose of having representative quantities, of economical and convenient size, from a section, or from the whole of a lot of material, for examination and test, so that an agreement may be reached in regard to the following:

(*a*) The extent of variation of qualities in different portions of the lot;

(*b*) The average quality of the whole lot of material.

Scope. 2. These methods of sampling are for use in obtaining representative portions of stocks or shipments of petroleum and all petroleum products, except gases.

GENERAL CONSIDERATIONS

Personnel. 3. No set of directions for sampling, however explicit, can take the place of judgment, skill and previous experience on the part of the persons actually engaged in the sampling and in the supervision of the sampling. These directions are intended to supplement this experience and particularly to serve as a guide in the selection of the method which is to be used in common by each of two or more contracting parties.

Grades of Material. 4. The materials sampled may be graded as follows:

(*a*) Crude or unrefined materials, such as petroleum from wells, pipe lines, and tanks.

(*b*) Semi-refined materials, such as fuel oil, and gas oil.

(*c*) Refined products, such as gasoline, lubricating oils, and insulating oils.

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[1] Criticisms of these Tentative Methods are solicited and should be directed to Mr. R. P. Anderson, Secretary of Committee D-2 on Petroleum Products and Lubricants, 250 Park Ave., New York City.

Classes of Material.

5. For sampling purposes, material may be classified as follows:

(*a*) Liquid materials, such as light crude oils, gas oils, lubricating oils, and naphthas.

(*b*) Semi-liquid and highly viscous materials, such as cylinder stocks, and heavy fuel oils.

(*c*) Soft solid and semi-solid materials, such as asphalts, waxes, petrolatum, and greases.

(*d*) Lumpy solid materials, such as petroleum coke.

Types of Containers.

6. These methods apply to material in the following types of containers:

(*a*) Cans or small containers (up to 10 U. S. gal., inclusive);
(*b*) Drums or barrels;
(*c*) Tank cars or tank trucks;
(*d*) Shore tanks;
(*e*) Ship tanks or barge tanks;
(*f*) Pipe lines;
(*g*) Bags;
(*h*) Cakes;
(*i*) Bulk or loose form.

Character of Tests.

7. Samples are taken for the following types of tests:
(*a*) General quality tests.
(*b*) Definite chemical and physical tests.
(*c*) Special quality tests.

Disposition of Samples.

8. Samples are used for one or more of the following purposes:
(*a*) Visual examination.
(*b*) Laboratory test.
(*c*) Preservation for record.
(*d*) Check and referee tests.

Marking Samples.

9. Samples should be marked, recorded, and handled throughout in accordance with all the usual precautions of the best laboratory technique.

DEFINITIONS

Average Sample.

10. *Average Sample.*[1]—An average sample would be one so taken as to contain parts from all sections of the container or pipe in proportion to the volume of each part.

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[1] It is practically impossible to obtain an average sample, except, perhaps, through a continuous sampling connection from a vertical run in a pipe line with specially constructed draw-off pipes, or by vigorously agitating and stirring the contents of a vessel and drawing off a sample while the contents are still agitated. Samples obtained by lowering and raising a bottle while allowing it to fill have been considered average samples, but obviously the proportions are not related to the tank volumes at the various levels.

All-Levels Sample.

11. *All-Levels Sample.*[1]—An all-levels sample is one obtained by submerging a closed sample container to a point as near as possible to the draw-off level, opening it and raising it at such a rate that it will be nearly but not quite full when withdrawn.

Upper Sample.

12. *Upper Sample.*—An upper sample is one taken at a point 10 per cent of the depth of a uniform cross-section vessel or 10 per cent of the diameter of a horizontal cylindrical tank below the surface.

Middle Sample.

13. *Middle Sample.*—A middle sample is one taken at half the depth of the material.

Lower Sample.

14. *Lower Sample.*—A lower sample is one taken at a point 10 per cent of the depth of a uniform cross-section vessel or 10 per cent of the diameter of a horizontal cylindrical tank above the bottom of the vessel.

Composite Sample.

15. (*a*) *Composite Sample.*—A composite sample is a mixture of upper, middle and lower samples containing, for vessels of different shapes, volume proportions which correspond approximately to the volumes of the material at these levels, as follows:

	COMPOSITE SAMPLE PROPORTIONS	
	UNIFORM CROSS-SECTION VESSELS	HORIZONTAL CYLINDRICAL TANKS (ASSUMED FULL)
Upper Sample	1 part	1 part
Middle Sample	3 parts	8 parts
Lower Sample	1 part	1 part

(*b*) For horizontal cylindrical tanks that are only partially filled, the simple geometrically proportioned sampling levels, and composite sample mixtures stated above cannot give samples that are substantially proportionate to the volumes at the different depths, unless the tanks are filled to at least 80 per cent of the diameter. Each tank level may be worked out in accordance with the principle stated in Section 10.

(*c*) In referee tests, a mutually satisfactory selection of sampling levels and sample quantities at each level shall be mutually agreed upon if any departure from the methods specified are to be allowed.

(*d*) Table I gives a set of substantially correct sampling levels and sample quantities for partially filled horizontal cylindrical tanks, which may be used in the absence of other arrangements, employing values in the tabulation that lie nearest to the *actual filling depth.*

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[1] The all-levels sampling method is widely used for ship tanks, barges and large shore tanks. The method can not, however, give an average or a strictly representative sample, not only because the tank volume may not be proportional to the depth and because the operator can not move the sample container with a uniform speed, but also because the rate of filling the sample container is proportionate to the square root of the depth of immersion of the sample container opening below the surface.

Continuous Sample.

16. *Continuous Sample.*—A continuous sample is one obtained from a pipe or conduit conveying the material, in such a manner as to give at all times a representative average of all the sections and section velocities of the stream throughout the period of transit.

Dipper Sample.

17. *Dipper Sample.*—A dipper sample is one taken by interposing a dipper or collecting vessel into the path of a free flowing stream, so as to collect a definite volume from the full cross-section of the stream at regular time intervals, or at time intervals so varied as to obtain samples in proportion to the amounts being delivered.

Mixed Sample.

18. *Mixed Sample.*—A mixed sample is one obtained by mixing or vigorously stirring the contents of the original container and pouring out or drawing off the quantity desired.

Thief Sample.

19. *Thief Sample.*—A thief sample is one taken by means of a sampling tube from a specified point in the containing vessel being sampled.

TABLE I.—SAMPLING LEVELS AND SAMPLE QUANTITIES FOR PARTIALLY FILLED HORIZONTAL CYLINDRICAL TANKS

Liquid Depth, Percentage of Diameter	Sampling Level, Percentage of Diameter Above Bottom			Quantity of Sample to be Taken at Each Sampling Level		
	Upper	Middle	Lower	Upper	Middle	Lower
10	..	..	5	..	..	10 parts
20	..	..	10	..	..	10 "
30	..	20	10	..	6 parts	4 "
40	..	25	10	..	7 "	3 "
50	..	30	10	..	8 "	2 "
60	55	35	10	1 part	8 "	1 part
70	65	40	10	1 "	8 "	1 "
80	75	45	10	1 "	8 "	1 "
90	85	50	10	1 "	8 "	1 "
100	90	50	10	1 "	8 "	1 "

Drain Sample.

20. *Drain Sample.*[1]—A drain sample is one taken by opening the draw-off or the discharge valve and drawing off a suitable portion of the material.

Bottom Sample.

21. *Bottom Sample.*[1]—A bottom sample is one obtained by collecting a portion of the material lying on the bottom surface of the tank, container or line at its lowest point.

Borings Sample.

22. *Borings Sample.*—A borings sample is one obtained by collecting the chips made by boring holes with a ship auger from top to bottom of the material contained in a barrel, case, bag, or cake.

Grab Sample.

23. *Grab Sample.*—A grab sample is one obtained by collecting representative portions from loose solids in equal quantities from each part or package of a shipment, in sufficient amount to be representative of all the sizes and components.

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[1] Occasionally, as in tank cars, the drain sample will also give a bottom sample.

Drain samples and bottom samples are usually taken only in order to examine for moisture, sludge, scale, etc., and in some cases for the purpose of drawing off any free water or extraneous material.

GENERAL DIRECTIONS AND PRECAUTIONS

Official Samples.

24. Official samples shall be taken by, or under the immediate supervision of, a person of judgment, skill and previous experience in sampling.

Representativeness.

25. The portions taken for samples shall represent the general character and average condition of the lot sampled.

Check Samples.

26. If there is any substantial reason indicating that a sample or set of samples may not be fully representative, another sample or set of samples shall be taken.

Care of Crude Materials.

27. Great care and good judgment are necessary in taking and handling samples from crude or unrefined materials, not only because of possible segregation, sludging and volatilization, but because of the bearing upon value, refining problems, and methods of handling.

Care of Semi-Refined Materials.

28. A high degree of care shall be employed in handling samples from semi-refined materials upon which definite chemical and physical tests are usually made.

Special Precautions, Refined Materials.

29. The utmost precautions and the most meticulous care shall be exercised in handling samples from refined products, upon which special quality tests are usually made.

Contamination.

30. For all grades of materials, precautions shall be taken to assure that the sampling apparatus and the samples themselves are neither contaminated with *nor altered by any material* not representative of the lot being sampled.

Cleanliness of Operator.

31. The operator engaged in sampling shall have clean hands, free from any material (unless it be the material being sampled). Cleaned gloves may be worn, but only when absolutely necessary, as in extremely cold weather, or in handling materials at high temperatures, or materials involving some health or other hazard.

Cleanliness of Sampling Apparatus.

32. The sampling apparatus shall be thoroughly clean and dry, and free from any substance that will dissolve into and/or color water-white gasoline.

NOTE.—*Exception:* Crude and dark-colored semi-refined materials (such as dark-colored fuel oils) when fluid enough to drain completely from sampling apparatus (Saybolt universal viscosity less than 250 at 100° F.) may be sampled repeatedly with apparatus that has been hung up and thoroughly drained.

Marking and Recording Samples.

33. Samples shall be permanently marked (preferably with a pencil hard enough to dent the paper)[1] immediately after collection with the date, also the hour and minute for continuous and dipper samples, name of the sampler, name or number and owner of vessel, barge, car or container; material sampled, and a reference symbol or

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[1] Soft pencil and ink markings are liable to obliteration from moisture, handling or smearing with oil.

number. Thin aluminum strips stamped with the sample number and other information are acceptable. The reference symbol or number and other markings should be entered in a bound record book.

Protection and Preservation of Samples.

34. Sample containers shall be closed immediately after collection. Sample containers shall be of such types as will protect the sample from contamination or deterioration. Specific precautions shall be taken as follows:

(*a*) Corks, for bottles, shall be clean, free from holes and loose bits of cork.

(*b*) Sealing wax, or paraffin, shall *not* be poured over corks after filling.

(*c*) Light-sensitive samples, when placed in bottles, shall be wrapped or otherwise covered at once, to protect them from light.

(*d*) Tin cans with screwed or overlapped and soldered caps are acceptable, but only if the inside has been scrupulously cleaned and known to be free from dirt, water, washing compounds, naphtha or other solvents, soldering flux or acids, corrosion, rust, and pin holes.

(*e*) Refined materials should be further protected by covers of paper or metal-foil over the stopper and top to keep moisture and dust away from the filling and emptying opening, and to protect it from contact with the hands. Covers also prevent sealing substances, such as wax or paraffin, from getting on the lip when the seal is made or later opened, and so getting into the sample when it is poured out.

(*f*) Samples shipped by mail, express or messenger shall be well packed to avoid spillage, leakage, breakage, and loss by evaporation or alteration while in transit.

Volatile Samples.

35. Volatile samples shall be protected from evaporation while being collected, particularly in the case of continuous and dipper samples, and at once placed in closed containers.

Time and Place of Sampling.

36. Samples shall, if possible, be taken at the time of loading of a shipment and at the point of origination of a shipment. When sampling at the point of origin has not been provided for, or is not feasible, then the sampling shall be carried out as soon as possible after receipt of the shipment.

Number of Packages Sampled.

37. Shipments consisting of a number of separate packages, such as cans, drums, barrels, or boxes, shall have a number opened and sampled equal to the cube root (or the next larger whole number) of the total number of packages in the lot.

Quantity and Sub-division of Samples.

38. (*a*) *Individual Liquid Samples.*—Individual liquid samples taken with a beaker, bottle or dipper shall be approximately 1 qt. or 1 liter.

(*b*) *Composite Liquid Samples.*—Composite liquid samples taken from vessels of all kinds and sizes shall be at least 5 qt. (or 5 liters) for vessels of uniform cross-section and 10 qt. (or 10 liters) for horizontal cylindrical tanks.

(*c*) *Gross Liquid Mixed Cargo Samples.*—Gross liquid mixed cargo samples taken from the various ship tanks shall have a total gross quantity corresponding to the number of tanks, that is, multiples of 5 to 10 qt., depending on the tank shapes.

(*d*) *Liquid Samples Taken by the Continuous Method or by the Dipper Method.*—Liquid samples taken by the Continuous Method, Section 50, or by the Dipper Method, Section 53, shall be approximately 0.1 per cent of the total quantity shipped, but not less than 5 U. S. gal. (or 20 liters) nor more than 40 U. S. gal. (or 160 liters).

(*e*) *Soft Solid Samples* (*Waxes, etc.*).—Soft solid samples taken by the Borings Method, Section 62, shall consist of three sets of borings $\frac{3}{4}$-in. in diameter and approximately the depth of the material.

(*f*) *Lumpy Solid Samples.*—Lumpy solid samples taken by the Grab Method, Section 65, shall be equivalent to approximately 0.1 per cent of the lot, but not less than about 50 lb. (25 kg.) nor more than 1000 lb. (500 kg.).

(*g*) *Sub-division of Gross Samples.*—Sub-division of gross samples shall be carried out in the laboratory and should be performed by someone from the laboratory staff, rather than by the person who originally took the samples. The sub-division shall be carried out in accordance with careful laboratory practice and the detailed directions given as a part of the procedure for each method.

CHOICE OF SAMPLING METHODS

Existing Sampling Methods.

39. (*a*) Where standard or tentative standard methods for sampling of the American Society for Testing Materials are already in existence, they shall be followed in detail in addition to the more general requirements appearing in these methods, and shall supersede them if there is a conflict.

NOTE.—Specifically this includes the following methods of sampling of the American Society for Testing Materials:

Standard Method of Sampling Coal (Serial Designation: D 21);[1]

Standard Methods of Laboratory Sampling and Analysis of Coal and Coke (Serial Designation: D 271);[1]

Standard Methods of Sampling Bituminous Materials (Serial Designation: D 140).[1]

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[1] 1927 Book of A.S.T.M. Standards, Part II.

Sampling Requirements in Existing Test Methods.

(*b*) Where special conditions exist in regard to the quality of the material and/or the method of test, and particularly when existing standard or tentative standard methods of tests of the American Society for Testing Materials call for special precautions or methods for sampling, they shall be followed in detail in addition to the requirements appearing in these methods and shall supersede them if there is a conflict.

NOTE.—Specifically this includes the following methods of test of the American Society for Testing Materials:

Standard Methods of Testing Electrical Insulating Oils (Serial Designation: D 117);[1]

Standard Method of Analysis of Grease (Serial Designation: D 128);[1]

Tentative Method of Test for Penetration of Greases and Petrolatum (Serial Designation: D 217 - 27 T).[2]

Alternative Sampling Methods.

40. Alternative methods for sampling shall be employed only after a mutually satisfactory agreement shall have been reached by persons authorized to act on this question. The agreement shall be put in writing and signed by competent officials.

Liquid Materials.

41. Liquid materials may be sampled by the Bottle or Beaker Thief, Continuous, or Dipper Method, in accordance with the type of container, as described below:

Cars and Tanks.

(*a*) Tank cars, tank trucks, shore tanks, ship tanks and barge tanks shall be sampled by the Bottle or Beaker Method as described in Sections 45, 46, and 47, for upper, middle and lower samples (Sections 12, 13 and 14), from which a composite sample for all referee tests shall be made up in accordance with Section 15.

The all-levels sample, Section 11, is convenient in practice but shall be employed for routine work only.

Pipe Lines.

(*b*) Pipe lines shall be sampled by the Continuous Method as described in Sections 48, 49 and 50.

Small Pipe and Open Discharge Lines.

(*c*) Small pipe lines (approximately 2 in. in diameter or less) ending in an open discharge, or where an open discharge is permissible, may be sampled by the Dipper Method as described in Sections 51, 52 and 53. In the absence of an open discharge, a larger diameter pipe nipple may be placed in a vertical section of the pipe line and the Continuous Method used as described in Sections 48, 49 and 50.

Cans, Drums or Barrels.

(*d*) Cans, drums or barrels shall be sampled by the Thief Method as described in Sections 54 to 59, inclusive, except that small cans, 1 gal. or less, *may* be taken complete. Containers shall have their contents thoroughly mixed by being rolled or shaken to allow the taking of a mixed sample, Section 18, with the thief.

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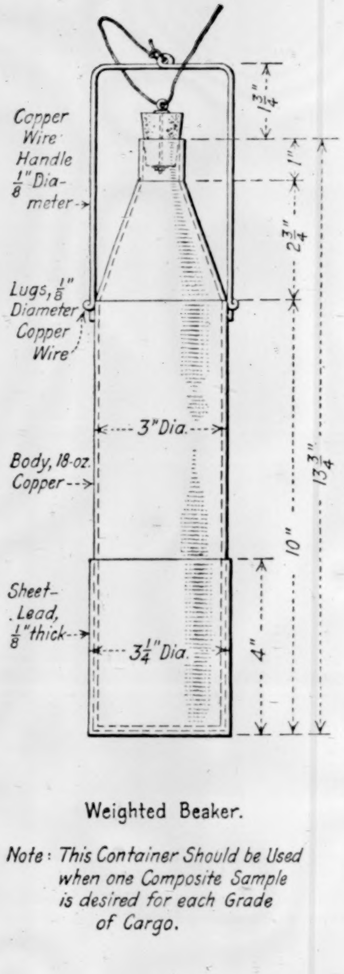
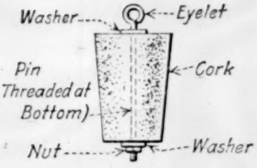
[1] 1927 Book of A.S.T.M. Standards, Part II.

[2] See p. 930.

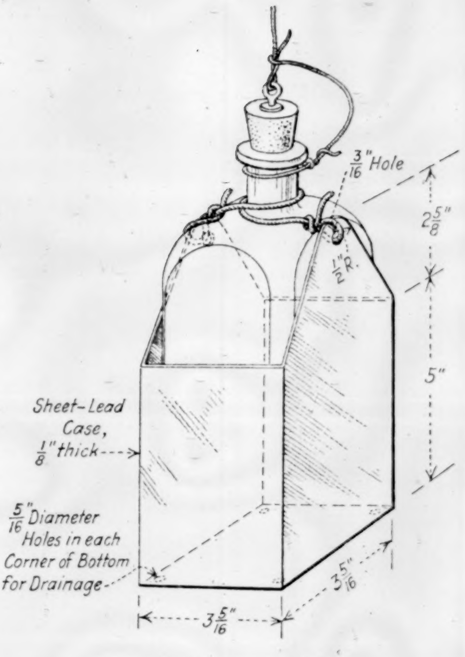

Copper Wire Handle 1/8" Diameter
1 3/4"
1"
2 3/4"
Lugs, 1/8" Diameter Copper Wire
3" Dia.
Body, 18-oz. Copper
13 3/4"
10"
Sheet-Lead, 1/8" thick
3 1/4" Dia.
4"

Weighted Beaker.

Note: This Container Should be Used when one Composite Sample is desired for each Grade of Cargo.


Washer
Eyelet
Pin (Threaded at Bottom)
Cork
Nut
Washer

Detail of Cork Arrangement.


3/16" Hole
2 5/8"
1/2" R.
5"
Sheet-Lead Case, 1/8" thick
5/16" Diameter Holes in each Corner of Bottom for Drainage
3 5/16"
3 5/16"

Weighted Bottle.

Note: This Bottle to be used for Obtaining the Individual Samples when Individual Samples are to be kept Separate, that is whenever the Sample must be delivered to the Laboratory in the same Container in which it was contained.

FIG. 1.—Standard Sampling Containers for Bottle or Beaker Sampling.

Semi-Liquid Materials. 42. Semi-liquid materials shall be warmed till they are sufficiently fluid to be sampled as liquid materials as described in Section 41.

Soft Solid Materials. 43. Soft solid materials shall be sampled by the Borings Method as described in Sections 60, 61 and 62.

Lumpy Solid Materials. 44. Loose lumpy solid materials shall be sampled by the Grab Method as described in Sections 63, 64 and 65.

BOTTLE OR BEAKER SAMPLING

Scope. 45. The bottle or beaker method of sampling is applicable to the following types of containers:

(*a*) Tank cars and/or tank trucks;

(*b*) Shore tanks;

(*c*) Ship tanks and barge tanks.

APPARATUS[1]

Sampling Bottle and Beaker. 46. The sampling bottle and sampling beaker shall be made substantially in accordance with the form and dimensions shown in Fig. 1, with the size of opening as follows:

	SIZE OF OPENING	
CLASS OF MATERIAL	WEIGHTED SAMPLING BOTTLE	WEIGHTED SAMPLING BEAKER
Heavy crudes and fuel oils	...	1½ in.
Light crudes and full cargoes of Diesel fuels, distillates or non-transparent gas oils	...	¾ in.
Heavy lubricating oils	1½ in.	...
Light lubricating oils, kerosine, gasoline, transparent gas oils, also part cargoes of Diesel fuel, distillates or non-transparent gas oils	¾ in.	...

PROCEDURE[2]

Procedure. 47. The following instructions shall apply to a substantially full tank.

(*a*) An upper sample shall be taken by lowering the weighted stoppered bottle or beaker till its mouth is 10 per cent of the depth of a tank of uniform cross-section or diameter of a horizontal cylindrical tank below the surface, uncorking it by a quick jerk, allowing it to fill completely, as evidenced by cessation of air bubbles, and then immediately withdrawing it.

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[1] This description is adapted from "Instructions for Measuring, Sampling and Testing Bulk Oil Cargoes," Standard Oil Co. of New Jersey, pp. 20–22 (1926).

[2] This procedure is adapted from "Instructions for Measuring, Sampling and Testing Bulk Oil Cargoes," Standard Oil Co. of New Jersey, p. 21 (1926).

(*b*) Three middle samples shall be taken in a similar manner from a tank of uniform cross-section and eight middle samples from a horizontal cylindrical tank with the bottle or beaker mouth lowered to the middle of the tank.

(*c*) A lower sample shall be taken in a similar manner with the bottle or beaker mouth lowered to a point 10 per cent of the depth of a tank of uniform cross-section or diameter of a horizontal cylindrical tank above the bottom of the tank.

(*d*) The upper, middle, and lower samples from each tank car, tank truck, shore tank, individual ship tank or barge tank shall be combined into a composite sample.

(*e*) The composite samples taken with the beaker from the various ship tanks shall be combined into a mixed cargo sample for:

All Unfinished Products, including crude oils and bunker fuel;
Full Cargoes of Diesel fuel, distillates, and non-transparent gas oils.

(*f*) The beaker samples shall be poured as taken into a clean 5 or 10-gal. can, or cans, and the cans closed and covered, labeled and delivered to the laboratory, shaken or mixed with the churn dasher type of stirrer, Section 49 (*b*), and portions withdrawn by means of a thief for test.

(*g*) The composite samples taken with the bottle from the various ship tanks shall be kept separate and delivered separately to the laboratory for:

All Finished Products, including gasoline, kerosine, lubricating oils, and transparent gas oils;
Part Cargoes of Diesel fuel, distillates, and non-transparent gas oils.

(*h*) The bottle samples shall all be delivered to the laboratory in the bottle in which they were taken.

(*i*) When loading or discharging any finished product, samples shall also be taken from the shore tanks and at frequent intervals from the shore pipe line on the dock. These samples shall also be tested whenever it seems advisable.

(*j*) A portion of all samples from all shipments shall be fully labeled and kept in storage until the final disposition of the material.

(*k*) Ship and barge tanks should be sampled not only immediately after loading, but also before discharging.

CONTINUOUS SAMPLING

48. The continuous method of sampling is applicable to the following conditions and types of containers: **Scope.**

(*a*) Pipe lines;
(*b*) Filling lines;
(*c*) Transfer lines.

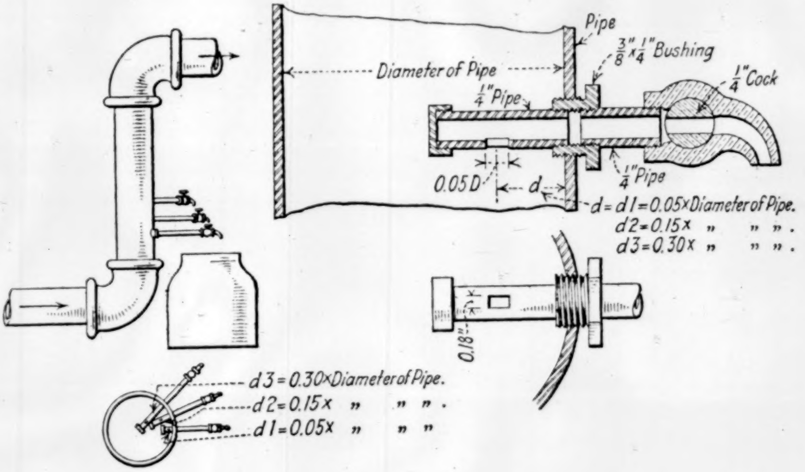
Pipe
$\frac{3}{8}$"×$\frac{1}{4}$" Bushing
$\frac{1}{4}$" Cock
Diameter of Pipe
$\frac{1}{4}$" Pipe
$\frac{1}{4}$" Pipe
0.05D
d
d = d1 = 0.05×Diameter of Pipe.
d2 = 0.15× " " ".
d3 = 0.30× " " ".
0.18"
d3 = 0.30×Diameter of Pipe.
d2 = 0.15× " " ".
d1 = 0.05× " " "

FIG. 2.—Continuous Sampling Connection.

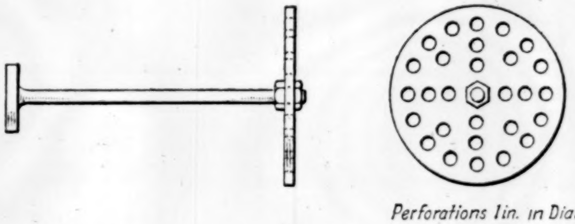
Perforations 1in. in Diameter.

FIG. 3.—Churn Dasher Type of Stirrer.

APPARATUS

49. (*a*) The continuous sampling connection shall be constructed and installed in accordance with the form and dimensions shown in Fig. 2. **Continuous Sampling Connection.**

(*b*) The churn dasher type of stirrer shall conform to the form and dimensions shown in Fig. 3. **Churn Dasher Stirrer.**

PROCEDURE[1]

Procedure. 50. The three plug cocks shall be opened, as nearly as possible, to the same angle of opening, so that a steady stream is drawn off from each cock and at such a rate as will allow about 0.1 per cent of the stream to be diverted during the passage of the lot being sampled, but not more than 40 U. S. gal. The following precautions should be observed.

(*a*) For semi-liquid materials, the receiver, or receivers, shall be kept warm by means of steam coils adjusted to keep the material just above the liquefying temperature.

(*b*) The receiver, or receivers, should be kept covered and closed except for their vents and filling stream openings, or pipes.

(*c*) Screens of larger area than the openings may be placed around the $\frac{1}{4}$-in. pipes or $\frac{1}{4}$-in. screen fittings inserted in the drip lines.

(*d*) A pipe cap with a suitable orifice hole may be substituted for the cocks, where the orifice size has been predetermined so as to give the right amount of sample.

(*e*) The gross continuous sample as collected shall be stirred with the churn dasher type of stirrer, or mixed by rolling or shaking, and then sampled by means of a thief to get a 1-qt. sample, or more where larger quantities may be desired and are called for.

DIPPER SAMPLING

Scope. 51. The dipper method of sampling is applicable where a free or open discharge of a stream exists or can be obtained readily, as follows:

(*a*) Small filling and transfer pipe lines (2 in. in diameter or less);

(*b*) Package, can or barrel filling apparatus.

APPARATUS

Dipper. 52. The dipper shall have a flared bowl holding approximately 1 qt. (or 1 liter) and a handle of any convenient length. Tinned steel is acceptable.

PROCEDURE[1]

Procedure. 53. (*a*) The dipper shall be inserted in the free flowing part of the stream, collecting a sample from the full cross-section of the stream at regular intervals, and the sample collected poured into a clean can of a convenient size, such as 5 or 10-gal. capacity.

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[1] This procedure has been adapted from the Standard Methods of Sampling Bituminous Materials (Serial Designation: D 140) of the American Society for Testing Materials, 1927 Book of A.S.T.M. Standards, Part II.

(*b*) If the pumping or delivery rate varies, the samples shall be taken at time intervals so chosen as to give a sample for equal pumped quantities.

(*c*) The container into which the individual dipper samples of approximately 1 qt. each are poured shall be kept closed and covered except when the close-fitting lid and cover are lifted to pour in the dipper sample.

(*d*) The gross amount of material collected should be about 0.1 per cent of the quantity transferred, and the time intervals should be so chosen as to correspond, but not less than 5 gal. nor more than 40 gal. should be collected.

(*e*) The 5 or 10-gal. can shall be closed and covered, labeled and delivered to the laboratory, where it shall be shaken or mixed with the churn dasher type of stirrer and portions withdrawn by means of a thief for test.

THIEF SAMPLING

54. The thief method of sampling is applicable to the following types of containers: **Scope.**

(*a*) Cans;
(*b*) Drums or barrels;
(*c*) Tanks cars.

APPARATUS

55. (*a*) A convenient and simple thief (see Fig. 4) for use with 50-gal. drum containers may be made of tinned steel as follows: Length 36 in. and diameter 1¼ in., with cone-shaped caps over the ends and having openings at the ends ⅜ in. in diameter. Three legs equally spaced around the thief at the bottom, long enough to hold the opening ⅛ in. from the bottom of the container being sampled, aids in securing a good representative sample. Two rings soldered to opposite sides of the tube at the upper end will be found convenient for holding the thief by slipping two fingers through them, leaving the thumb free to close the opening. **Sampling Thief.**

(*b*) For tank cars, a thief employing a trap at the bottom may be used.

(*c*) When sampling a shipment of oil, enough thiefs should be provided to insure drainage of each before it is used a second time. For obtaining only a few samples, two or three thiefs are enough, but for sampling a car lot of drummed oil, six or more are desirable.

56. Tin cans, or clear glass cork-stoppered bottles in cartons may be used. Containers shall be thoroughly clean and dry. **Containers for Samples.**

NOTE.—The glass bottle offers the advantage that it may be examined to see that it is clean. It also allows visual inspection of the oil before testing, particularly as regards free water and solid impurities. However, if samples are placed in glass bottles, they shall be kept in the dark until the portions are removed for testing for color and sludge forming characteristics, as light produces changes in these properties. Rubber stoppers should never be used with the glass containers. Only good quality cork should be used with a new cork for each sample. Contact of the oil with the cork may be prevented by means of wrapping around the cork before forcing it into the mouth of the bottle some metal-foil or a similar material not attacked by oil. The tin can fitted with a screw cap protected with a non-absorbent gasket will endure harder usage. Tin cans should be soldered on the exterior surfaces.

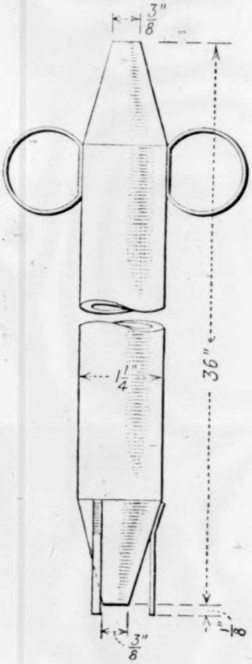

FIG. 4.—Drum Thief for Sampling.

Cleaning of Sampling Apparatus.

57. All thiefs and sample receptacles shall be thoroughly cleaned before using, special care being taken that no lint or other fibrous material remains in or on them.

NOTE.—It is suggested that the thiefs be cleaned by rinsing with oil-free gasoline and dried in the hot cabinet (see Section 58) before using. The best procedure is to rinse them after the sampling has been finished and then place them in the hot cabinet. They will in this way be ready for use without further cleaning when the next shipment is to be sampled.

All sample containers before using should be rinsed with oil-free gasoline and dried. They should then be washed with strong soapsuds, rinsed thoroughly with water and then dried in an oven at 105 to 110° C. A similar washing will be sufficient for re-use of the containers for samples of new oil, but those for used oil should be washed with both gasoline and benzol before using soapsuds. Containers which are not thoroughly clean and dry are likely to contaminate the sample of oil and cause misleading results in some of the tests.

Storage of Sampling Apparatus.

58. When not in use, all sampling apparatus should be kept in a hot, dry, dust-free cabinet or compartment at a temperature of not less than 38° C. (100° F.). Containers for samples, after washing and drying as indicated in Section 57, shall be kept unstoppered while in the oven or hot cabinet, but shall be closed immediately after they are taken out of the hot cabinet. However, it is permissible to prepare containers in advance, leaving them in the 105 to 110° C. oven until dry, then removing, corking or capping and sealing by dipping the neck into melted paraffin wax. Bottles shall, before dipping, have cork and neck wrapped with paper, securely tied. If this procedure is followed, before removing the cork or cap preparatory to filling the bottle or can with the sample, care shall be taken to remove the paraffin so as to prevent its contaminating the sample. Thiefs shall be kept at all times in a vertical position in the hot cabinet in a rack having a suitable drainage receptacle at the base.

PROCEDURE[1]

Procedure.

59. (*a*) Drums and barrels of oil to be sampled should be lined up preferably on the side and numbered, bungs up. The bungs shall be unsealed and removed and laid with the oily side up beside the bung holes. The unstoppered sample receptacle may be placed on the opposite side of the bung hole. The top hole of the thief shall be left open and the thief thrust to the lowest point or recess of the container. When the thief is filled, it shall be closed, the thief quickly withdrawn and the contents allowed to flow into the sample receptacle. The lower holes shall not be closed with the fingers of the other hand. The free hand shall be used to guide the stream of oil by touching the thief only as necessary. The oil shall not be allowed to flow over the hand or fingers before it flows into the sample receptacle, nor shall any excess be allowed to flow over the drum and back into the drum through the open bung hole. When the sample receptacle is filled, it shall be closed quickly and the bung replaced in the container and tightened. The sample receptacle shall be taken to the testing laboratory as quickly as feasible.

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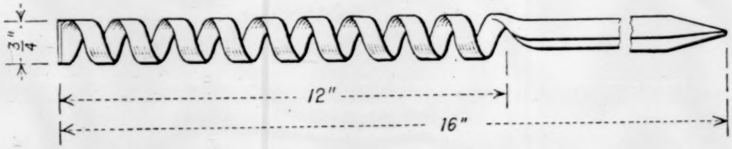
[1] This procedure has been adapted from the Standard Methods of Testing Electrical Insulating Oils (Serial Designation: D 117) of the American Society for Testing Materials, see 1927 Book of A.S.T.M. Standards, Part II.

(*b*) Drums or tank cars, etc., of oil shall not be sampled until the oil is at least as warm as the surrounding air. Electrical insulating oil is not hygroscopic, but cold oil may condense enough moisture on the surface from a humid atmosphere to seriously affect its insulating properties.

(*c*) Samples shall not be taken in a place exposed to rain and precautions shall be taken during sampling to protect both the material being sampled and the samples themselves from moisture and dust.

(*d*) Electrical insulating oil samples shall be taken only after the oil in the original container has been allowed to settle undisturbed for eight hours.

(*e*) The containers for oils other than electrical insulating oil shall have their contents thoroughly mixed by being rolled or shaken, so that a mixed sample may be taken with the thief.



Note: Greater Overall Lengths may be obtained when necessary to pass entirely through the Material to be sampled.

FIG. 5.—Improved Ship Auger.

BORINGS SAMPLING

Scope. 60. The borings method of sampling is applicable to wax and soft solids in cases, cakes, bags or barrels, when they cannot properly or conveniently be melted and sampled as liquids.

APPARATUS

Ship Auger. 61. The ship auger shall be $\frac{3}{4}$ in. in diameter and shall conform to the form and dimensions shown in Fig. 5, and be of such a length as to pass entirely through the material to be sampled.

PROCEDURE

Procedure. 62. (*a*) *Opening.*—Cases and barrels shall have the covers or heads removed. Bags shall have the mouths opened. Cakes shall have the wrappings, if any, opened.

(*b*) *Foreign Matter.*—If foreign substances, such as dirt, sticks, string, etc., appear upon the surface, they shall be removed. Foreign matter found in the interior shall be included, as it may come, with the borings.

(*c*) *Boring Hole Location.*—Three test holes shall be bored through the body of the material as follows:

One at the center;
One at one-quarter of the diameter (or width of the package) from the right side;
One at one-quarter of the diameter (or width of the package) from the left side.

(*d*) If any visible differences appear in the three sets of borings, they shall be preserved, examined and tested separately.

(*e*) If no visible differences appear in the borings they may be combined, preserved, examined and tested as a single sample, but this shall be done only after the three sets of borings have been delivered to the laboratory and by the laboratory tester.

(*f*) *Sub-division.*—If sub-division of the borings is desired, they may be chilled, pulverized if necessary for handling, mixed, and quartered till reduced to the amount desired, after their receipt in the laboratory. This sub-division shall not be done in the field by the sampler.

GRAB SAMPLING

63. The grab method of sampling is applicable to all lumpy materials loose in bins, bunkers, or carried in sacks, barrels or boxes. **Scope.**

APPARATUS

64. A shovel if employed for sampling[1] may be of any convenient size, but should have a width at least twice as great as the maximum dimension of the largest pieces sampled. **Apparatus.**

PROCEDURE[2]

65. (*a*) Solids are almost always heterogeneous in constitution. It is impossible to give absolutely definite and arbitrary methods for obtaining samples. Each problem must be worked out for itself, bearing in mind the particular conditions. **Procedure.**

(*b*) It is usually preferable to take samples during the unloading of cars or during transit of the material in conveyors. In such instances, a number of small samples should be taken at frequent and regular intervals from the material in transit and these samples combined to form a representative combined sample.

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[1] See the Standard Methods of Sampling Bituminous Materials (Serial Designation: D 140) of the American Society for Testing Materials, 1927 Book of A.S.T.M. Standards, Part II.

[2] The Standard Method of Sampling Coal (Serial Designation: D 21), 1927 Book of A.S.T.M. Standards, Part II, gives very full instructions and may be very helpful in directing the sampling of any loose bulk material.

(*c*) Occasionally, solids are tested as received in bags or barrels. In such instances, it is desirable to take a small sample from a number of packages selected at random and equivalent in number to the cube root (or the next larger whole number), of the total number of packages in the lot.

(*d*) Generally, samples taken from the bulk, in piles or cars, are unreliable and not representative. Where it is necessary to take such samples before the unloading of the car, small samples should preferably be taken from at least twelve spots throughout the bulk and these small samples collected to form the representative combined sample. In taking such small samples, it is desirable to take 8 samples from the corners of the car, 4 near the bottom and 4 near the top of the material. To those should be added 4 samples from the center of the car, 2 at the top, and 2 near the bottom of the material.

(*e*) The combined sample taken by any of the above methods should be in amount at least 0.1 per cent of the total bulk of material sampled. These combined samples should be carefully mixed and reduced in size to a convenient laboratory sample, by the standard method of quartering. In carrying out this quartering, a hard clean surface should be selected, free from cracks and protected from rain, snow, wind and beating sun. Cinders, sand, chips from the floor or any other material shall be avoided. The sample shall be protected from loss or gain in moisture or dust. The combined sample should be carefully mixed, spread out on the surface into a circular layer and divided into four equal quadrants. Two opposite quadrants shall be combined to form the representative reduced sample. If this sample is still too large for laboratory purposes, the quartering operation shall be repeated. In this manner, the sample shall finally be reduced to a size suitable for handling in the laboratory.

(*f*) The use of a riffle sampler as described in the Standard Methods of Laboratory Sampling and Analysis of Coal and Coke (Serial Designation: D 271) of the American Society for Testing Materials[1] is also recommended, with proper precautions against loss of dust for sub-division in the laboratory.

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[1] 1927 Book of A.S.T.M. Standards, Part II.

TENTATIVE METHOD OF TEST
FOR
CARBON RESIDUE OF PETROLEUM PRODUCTS[1]
(CONRADSON CARBON RESIDUE)

Serial Designation: D 189 – 27 T

This is a **Tentative Standard,** published for the purpose of eliciting criticism and suggestions, and as such is subject to annual revision.

ISSUED, 1924; REVISED, 1927.

Scope.

1. This method of test is a means of determining the amount of carbon residue left on evaporating an oil under specified conditions, and is intended to throw some light on the relative carbon-forming propensity of an oil. The results of the test must be considered in connection with other tests and the use for which the oil is intended. This test furnishes pertinent information relative to lubricants for internal combustion engines, domestic oil fuels, and oils used in the manufacture of gas.

APPARATUS

Apparatus.

2. The apparatus (see Fig. 1) shall consist of the following:

(*a*) Porcelain crucible, wide form, glazed throughout, or a silica crucible; 25 to 26-ml. (0.8-oz.) capacity, 46 mm. ($1\frac{7}{8}$ in.) in approximate rim diameter.

(*b*) Skidmore iron crucible, 60 to 80-ml. approximate capacity, 65 mm. ($2\frac{5}{8}$ in.) in outside diameter at the top, 37 to 39 mm. (about $1\frac{1}{2}$ to $1\frac{5}{8}$ in.) in height, supplied with a cover without delivery tubes and having the vertical opening closed. The horizontal opening shall be kept clean.

(*c*) Spun sheet-iron crucible, with cover; about 200-ml. (7-oz.) capacity, 80 mm. ($3\frac{1}{8}$ in.) in outside diameter at the top, 58 to 60 mm. (about $2\frac{3}{8}$ in.) in height, approximately 0.8 mm. ($\frac{1}{32}$ in.) in thickness and weighing, without cover, 70 to 75 g. (about $2\frac{1}{2}$ oz.). Place at the bottom of this crucible, and level before each test, a layer of about 25 ml. of dry sand, or enough to bring the Skidmore crucible with cover on, nearly to the top of the sheet-iron crucible.

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[1] Criticisms of this Tentative Method are solicited and should be directed to Mr. R. P. Anderson. Secretary of Committee D-2 on Petroleum Products and Lubricants, 250 Park Ave., New York City,

This procedure is a modification of the original Conradson method and apparatus for Carbon Test and Ash Residue in Petroleum Lubricating Oils. See *Proceedings*, Eighth International Congress of Applied Chemistry, New York, September, 1912, Vol. I, p. 131; also *Journal of Industrial and Engineering Chemistry*, Vol. 4, No. 11, December, 1912.

(*d*) Bare nichrome wire triangle having an opening small enough to support the bottom of the sheet-iron crucible at the same level as the bottom of the asbestos block or hollow sheet-metal box, Paragraph (*f*).

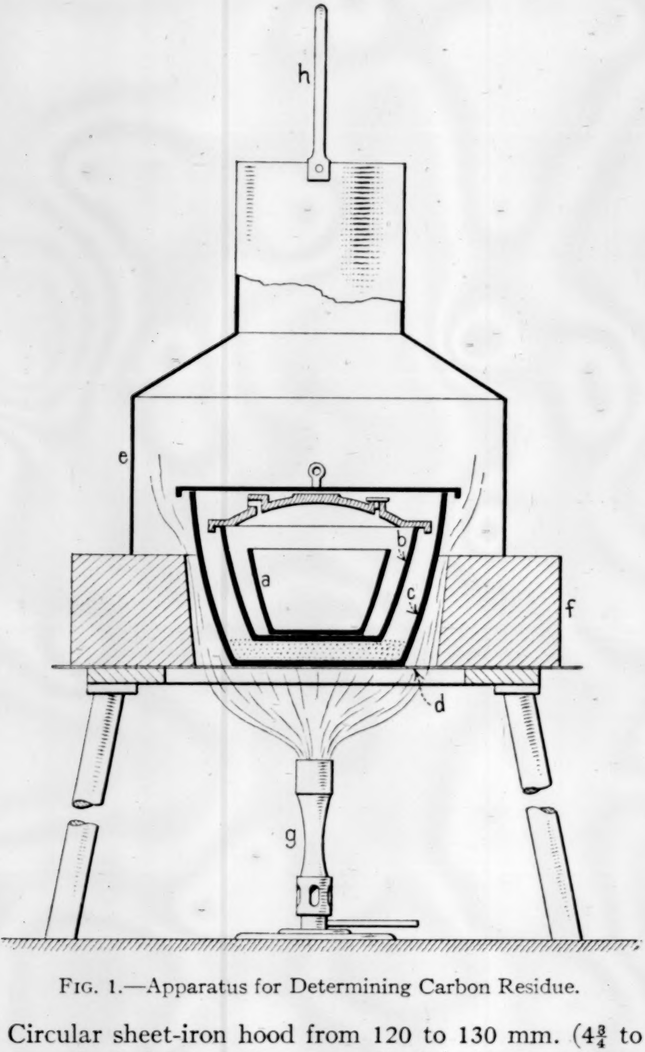

FIG. 1.—Apparatus for Determining Carbon Residue.

(*e*) Circular sheet-iron hood from 120 to 130 mm. ($4\frac{3}{4}$ to $5\frac{1}{4}$ in.) in diameter, the height of the perpendicular side to be from 50 to 53 mm. (2 to $2\frac{1}{8}$ in.); provided at the top with a chimney 50 to 60 mm. (2 to $2\frac{1}{2}$ in.) in height and from 50 to 56 mm. (2 to $2\frac{1}{4}$ in.) inside diameter, which is attached to the lower part having the perpendicular sides by a cone-shaped member, bringing the total height of the complete hood from 125 to 130 mm. ($5\frac{1}{8}$ in.). As a guide for the height of the flame above the chimney, a bridge of wire shall be attached having a height of 50 mm. (2 in.) above the top of the chimney.

(*f*) Asbestos block or hollow sheet-metal box, 150 to 175 mm. (6 to 7 in.) in diameter if round or on a side if square, 32 to 38 mm. ($1\frac{1}{4}$ to $1\frac{1}{2}$ in.) in thickness, provided with a metal-lined, inverted cone-shaped opening through the center; 83 mm. ($3\frac{1}{4}$ in.) in diameter at the bottom, and 89 mm. ($3\frac{1}{2}$ in.) in diameter at the top.

(*g*) Burner, Meker type, 24 mm. (1 in.) in diameter by 155 mm. (6 in.) in height, suitable for either manufactured or natural gas.

PROCEDURE

Procedure.

3. The test shall be conducted as follows:

Place two glass beads about 0.1 in. in diameter in, and include them in the weight of, the tared porcelain or silica crucible in which is accurately weighed 10 g. of the oil to be tested, free from moisture or other suspended matter. Place this crucible in the center of the Skidmore crucible. Level the sand in the large sheet-iron crucible and set the Skidmore crucible on it in the exact center of the iron crucible. Apply covers to both the Skidmore and the iron crucible, the one to the latter fitting loosely to allow free exit to the vapors as formed.

On a suitable stand, place the bare nichrome wire triangle and on it the asbestos block or hollow sheet-metal box. Next, center the sheet-iron crucible in the block with its bottom resting on top of the triangle, and cover the whole with the sheet-iron hood in order to distribute the heat uniformly during the process (see Fig. 1).

Apply heat with a high strong flame from the Meker-type gas burner, so that the pre-ignition period will be 10 minutes $\pm 1\frac{1}{2}$ minutes (a shorter time may start the distillation so rapidly as to cause foaming or too high a flame). When smoke appears above the chimney, immediately move or tilt the burner so that the gas flame plays on the sides of the crucible for the purpose of igniting the vapors. Then remove the heat temporarily, and before replacing adjust by screwing down the pinch-cock on the gas tubing so that the ignited vapors burn uniformly with the flame above the chimney but not above the wire bridge. Heat may be increased, if necessary, when the flame does not show above the chimney.

When the vapors cease to burn and no further blue smoke can be observed, readjust the burner and hold the heat as at the beginning so as to make the bottom and lower part of the sheet-iron crucible a cherry red and maintain for exactly 7 minutes. The total period of heating shall be 30 minutes ±2 minutes. There should be no difficulty in carrying out the test exactly as directed with the gas burner of the type named, using city gas (about 550 B. t. u.) with the top of the burner about 2 in. below the bottom of the crucible. The time periods shall be observed with whatever burner and gas is used.

Remove the burner and allow the apparatus to cool until no smoke appears, and then remove the cover of the Skidmore crucible (about 15 minutes). Remove the porcelain or silica crucible with heated tongs, place in the desiccator, cool and weigh. Calculate the percentage of carbon residue on the original sample.

TOLERANCES

Tolerances. 4. Weights of oil sample shall be accurate to within 5 mg. Tests shall be run in duplicate and repeated if necessary until the percentages of carbon residue differ by not more than 10 per cent from an average.

TENTATIVE METHOD OF TEST
FOR
CLOUD AND POUR POINTS OF PETROLEUM PRODUCTS[1]

Serial Designation: D 97 – 27 T

This is a **Tentative Standard,** published for the purpose of eliciting criticism and suggestions, and as such is subject to annual revision.

ISSUED, 1921; REVISED, 1922, 1923, 1925, 1927.

Cloud Point. 1. (*a*) The Cloud Point of a petroleum oil is that temparature at which paraffin wax or other solid substances begin to crystallize out or separate from solution when the oil is chilled under certain definite specified conditions.

Pour Point. (*b*) The Pour Point of a petroleum oil is the lowest temperature at which this oil will pour or flow when it is chilled without disturbance under certain definite specified conditions.

Scope. 2. (*a*) The test for cloud point shall be used only for oils which are transparent in layers $1\frac{1}{2}$ in. thick.

(*b*) The test for pour oil shall be used for all other petroleum oils and may be used for oils on which the test for cloud point is permitted.

APPARATUS

(See Fig. 1)

Test Jar. 3. The test jar, *a*, shall be of clear glass, cylindrical form, flat bottom, approximately $1\frac{3}{16}$ to $1\frac{5}{16}$ in. in inside diameter and $4\frac{1}{2}$ to 5 in. high. An ordinary 4-oz. oil sample bottle may be used if it is within the above requirements, and no test jar is available.

Thermometers. 4. The thermometer, *b*, shall conform to the requirements of one of the following specifications:

(*a*) These specifications cover a special thermometer graduated in either Centigrade or Fahrenheit degrees as specified, the ranges being -38 to $+50°$ C. or -36 to $+120°$ F., respectively.

TYPE: Etched stem, glass.

LIQUID: Mercury.

RANGE AND SUBDIVISION: -38 to $+50°$ C. in 1° C. or -36 to $+120°$ F. in 2° F.

TOTAL LENGTH: 220 to 224 mm. (8.69 to 8.81 in.).

STEM: Plain front, enamel back, suitable thermometer tubing. Diameter, 7.0 to 8.0 mm. (0.28 to 0.31 in.).

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[1] Criticisms of this Tentative Method are solicited and should be directed to Mr. R. P. Anderson, Secretary of Committee D-2 on Petroleum Products and Lubricants, 250 Park Ave., New York City.

Bulb: Corning normal or equally suitable thermometric glass.
Length, not over 9.5 mm. (0.37 in.).
Diameter, not greater than stem.

Distance to −38° C. or −36° F. Line from Bottom of Bulb: 120 to 130 mm. (4.73 to 5.12 in.).

Distance to +49° C. or +120° F. Line from Top of Thermometer: 19 to 25 mm. (0.75 to 0.98 in.).

Expansion Chamber: To permit heating to 100° C. or 212° F.

Filling above Mercury: Nitrogen gas.

Top Finish: Plain.

Graduation: All lines, figures, and letters clear cut and distinct. Lines at multiples of 5° C. or 10° F. to be longer than the remaining lines. Graduations to be numbered at each multiple of 10° C. or 20° F.

Immersion: 108 mm. or 4¼ in. The words "108-mm. immersion" on Centigrade thermometers or "4¼-in. immersion" on Fahrenheit thermometers and a line around the stem 108.0 mm. or 4.25 in. above the bottom of the bulb shall be etched on the thermometer.

Special Marking: "A.S.T.M. Cloud and Pour," a serial number and the manufacturer's name or trade mark shall be etched on the stem.

Scale Error: The error at any point of the scale, when the thermometer is standardized as provided below, shall not exceed 0.5° C. or 1° F.

Standardization: The thermometer shall be standardized at the ice point and at intervals of approximately 20° C. or 40° F. for 108-mm. or 4¼-in. immersion and for an average temperature of 21° C. or 70° F. for the emergent mercury column.

Case: The thermometer shall be supplied in a suitable case on which shall appear the marking: "A.S.T.M.Cloud and Pour, −38 to +50° C." or "A.S.T.M. Cloud and Pour, −36 to +120° F." according to the type of thermometer.

Note.—For the purpose of interpreting these specifications the following definitions apply:

The total length is the over-all length of the finished instrument.

The diameter is that measured with a ring gage.

The length of the bulb is the distance from the bottom of the bulb to the beginning of the enamel backing.

The top of the thermometer is the top of the finished instrument.

(*b*) These specifications cover a special low cloud and pour test thermometer graduated in either Centigrade or Fahrenheit degrees as specified, the ranges being −60 to +20° C. or −70 to +70° F.

Type: Etched stem, glass.

Liquid: Toluene or other suitable liquid colored red with a permanent dye.

Range and Sub-division: −60 to +20° C. in 1° C. or −70 to +70° F. in 2° F.

Total Length: 227 to 231 mm. (8.92 to 9.08 in.).

Stem: Plain front, enamel back, suitable thermometer tubing. Diameter 7.0 to 8.0 mm. (0.28 to 0.31 in.).

Bulb: Corning normal or equally suitable thermometric glass.
Length, 8.0 to 9.5 mm. (0.31 to 0.37 in.).
Diameter, 5.0 to 6.5 mm. (0.22 to 0.26 in.).

Distance to −57° C. or −70° F. Line from Bottom of Bulb: 120 to 130 mm. (4.73 to 5.12 in.).

DISTANCE TO +20° C. or +68° F. LINE FROM TOP OF THERMOMETER: 35 to 45 mm. (1.38 to 1.77 in.).

EXPANSION CHAMBER: To permit heating to +60° C. or +140° F.

FILLING ABOVE LIQUID: Gas under pressure.

TOP FINISH: Plain.

GRADUATION: All lines, figures and letters clear cut and distinct, lines at multiples of 5° C. or 10° F. to be longer than the remaining lines. Graduations to be numbered at each multiple of 10° C. or 20° F.

IMMERSION: 108 mm. ($4\frac{1}{4}$ in.). The words "108-mm. immersion" on Centigrade thermometers, or "$4\frac{1}{4}$-in. immersion" on Fahrenheit thermometers and a line around the stem 108 mm. (4.25 in.) above the bottom of the bulb, shall be etched on the thermometer.

SPECIAL MARKING: "A.S.T.M. Low Cloud and Pour" a serial number and the manufacturer's name or trade mark shall be etched on the thermometer.

SCALE ERROR: The error at any point of the scale when the thermometer is standardized as provided below, shall not exceed 1° C. or 2° F.

STANDARDIZATION: The thermometer shall be standardized at the ice point and at intervals of approximately 20° C. or 35° F. for 108-mm. or $4\frac{1}{4}$-in. immersion, and for an avergae temperature of 21° C. or 70° F. for the emergent liquid column.

CASE: The thermometer shall be supplied in a suitable case on which shall appear the marking "A.S.T.M. Low Cloud and Pour, −60 to +20° C." or A.S.T.M. Low Cloud and Pour, −70 to +70° F.," according to the type of thermometer.

NOTE.—For the purpose of interpreting these specifications, the following definitions apply:

The total length is the overall length of the finished instrument.

The diameter is that measured with a ring gage.

The length of the bulb is the distance from the bottom of the bulb to the beginning of the enamel backing.

The top of the thermometer is the top of the finished instrument.

5. The cork, *c*, shall fit the test jar, and shall be bored centrally to take the test thermometer. **Cork.**

6. The jacket, *d*, shall be of glass or metal, shall be water tight, of cylindrical form, flat bottom, about $4\frac{1}{2}$ in. deep, with inside diameter $\frac{3}{8}$ to $\frac{1}{2}$ in. greater than outside diameter of the test jar. **Jacket.**

7. A disk of cork or felt, *e*, $\frac{1}{4}$ in. thick and of the same diameter as the inside of the jacket will be required. **Cork Disk.**

8. The ring gasket, *f*, shall be about $\frac{3}{16}$ in. thick, and made to fit snugly around the outside of the test jar and loosely inside the jacket. This gasket may be made of cork, felt or other suitable material, elastic enough to cling to the test jar and hard enough to hold its shape. The purpose of the ring gasket is to prevent the test jar from touching the jacket. **Gasket.**

9. The cooling bath, *g*, shall be of a type suitable for obtaining the required temperatures. The size and shape of the bath are optional but a support, suitable for holding the jacket firmly in a **Bath.**

vertical position, is essential. For determination of very low pour points, a smaller insulated cooling bath may be used and the test jar placed directly in it. The required bath temperatures may be maintained by refrigeration if available, otherwise by suitable freezing mixtures.

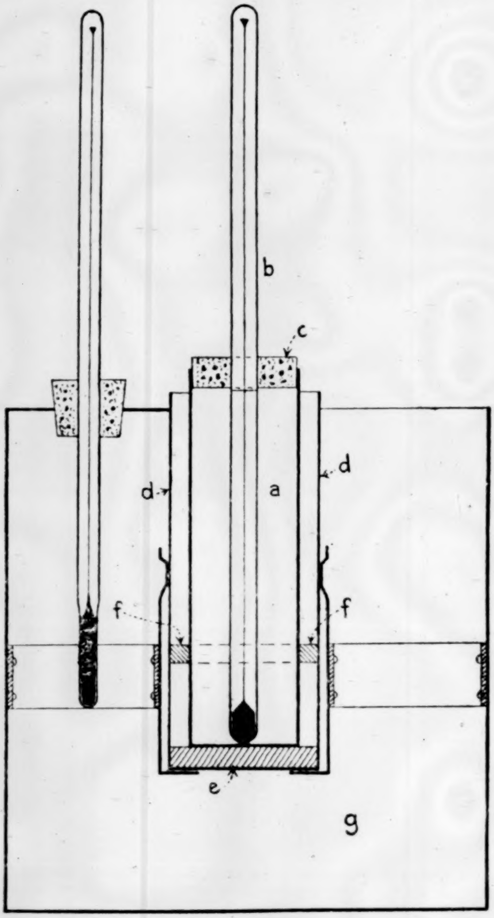

FIG. 1.—Apparatus for Cloud and Pour Test (as assembled for Cloud Test).

NOTE.—The freezing mixtures commonly used are as follows:

For temperatures down to	50° F., ice and water.
" " " "	10° F., crushed ice and sodium chloride.
" " " "	–15° F., crushed ice and calcium chloride.
" " " "	–70° F., solid carbon dioxide and acetone or gasoline.

The last named mixture may be made as follows: In a covered metal beaker chill a suitable amount of acetone or gasoline to 10° F., or lower, by means of an ice-salt mixture. Invert a cylinder of liquid carbon dioxide and draw off carefully into a chamois skin bag the desired amount of carbon dioxide, which through rapid evaporation will quickly become solid. Then add to the chilled acetone or gasoline enough of the solid carbon dioxide to give the desired temperature.

PROCEDURE

Procedure for Cloud Point.

10. The oil to be tested shall be brought to a temperature at least 25° F. above the approximate cloud point. Moisture, if present, shall be removed by any suitable method, as by filtration through dry filter paper until the oil is perfectly clear, but such filtration shall be made at a temperature at least 25° F. above the approximate cloud point.

The clear oil shall be poured into the test jar, *a*, to a height of not less than 2 nor more than $2\frac{1}{4}$ in. The test jar may be marked to indicate the proper level.

The test jar shall be tightly closed by the cork, *c*, carrying the test thermometer, *b*, in a vertical position in the center of the jar with the thermometer bulb resting on the bottom of the jar.

The disk, *e*, shall be placed in the bottom of the jacket, *d*, and the test jar with the ring gasket, *f*, 1 in. above the bottom shall be inserted into the jacket. The disk, jacket and inside of jacket shall be clean and dry.

The temperature of the cooling bath, *g*, shall be adjusted so that it is below the cloud point of the oil by not less than 15 nor more than 30° F. and this temperature shall be maintained throughout the test. The jacket, containing the test jar, shall be supported firmly in a vertical position in the cooling bath so that not more than 1 in. of the jacket projects out of the cooling medium.

At each test thermometer reading which is a multiple of 2° F., the test jar shall be removed from the jacket, quickly but without disturbing the oil, inspected for cloud, and replaced in the jacket. This complete operation shall require not more than three seconds.

When such inspection first reveals a distinct cloudiness or haze in the oil at the bottom of the test jar, the reading of the test thermometer, corrected for error if necessary, shall be recorded as the cloud point.

11. The oil shall be poured into the test jar, *a*, to a height of not less than 2 nor more than $2\frac{1}{4}$ in. When necessary, the oil shall be heated in a water bath just sufficiently for pouring into the test jar.

The test jar shall be tightly closed by the cork, *c*, carrying the test thermometer, *b*, in a vertical position in the center of the jar with the thermometer bulb immersed so that the beginning of the capillary shall be ⅛ in. below the surface of the oil.

Heat without stirring to a temperature of 115° F. in a bath maintained at not higher than 118° F. The oil shall then be cooled to 90° F. in air or in a water bath approximately 77° F. in temperature. Oils with which the low cloud and pour test thermometer can be used from the beginning of the test shall be cooled to 60° F. in any convenient manner before the thermometer is placed in position.

The disk, *e*, shall be placed in the bottom of the jacket, *d*, and the test jar, with the ring gasket, *f*, 1 in. above the bottom, shall be inserted into the jacket. The disk, gasket and inside of jacket shall be clean and dry.

After the oil has cooled enough to allow the formation of paraffin wax crystals, great care shall be taken not to disturb the mass of the oil nor to permit the thermometer to shift in the oil. Any disturbance of the spongy network of wax crystals will lead to low and fictitious results.

The temperature of the cooling bath, *g*, shall be adjusted so that it is below the pour point of the oil by not less than 15 nor more than 30° F. and this temperature shall be maintained throughout the test. The jacket, containing the test jar, shall be supported firmly in a vertical position in the cooling bath so that not more than 1 in. of the jacket projects out of the cooling medium.

Beginning at a temperature 20° F. before the expected pour point, at each test thermometer reading which is a multiple of 5° F., the test jar shall be removed from the jacket carefully and shall be tilted just enough to ascertain whether there is a movement of the oil in the test jar. The complete operation of removal and replacement shall require not more than three seconds. As soon as the oil in the test jar does not flow when the jar is tilted, the test jar shall be held in a horizontal position for exactly five seconds, as noted by a stop watch or other accurate timing device and observed carefully. If the oil shows any movement under these conditions, the test jar shall be immediately replaced in the jacket and the same procedure repeated at the next temperature reading 5° F. lower.

The test shall be continued in this manner until a point is reached at which the oil in the test jar shows no movement when the test jar is held in a horizontal position for exactly five seconds. Certain lubricating oils tend to move as a whole and should be very closely observed. The reading of the test thermometer at this temperature, corrected for error if necessary, shall be recorded. The pour point shall be taken as the temperature 5° F. above this solid point.

Special Procedure for Black Oils and Cylinder Stocks

12. (*a*) In those cases where it is known that a sample has been subjected to some temperature higher than 115° F. during the preceding 24 hours, or where the history of the sample in this respect is not known, the sample shall be held in the laboratory 24 hours before testing, unless threee consecutive tests of the same sample in the same test jar check results. For these particular oils this shall be called the upper (maximum) pour point.

(*b*) The lower (minimum) pour point shall be determined by heating a sample with stirring to 220° F. The oil shall then be poured in the test jar, cooled to 90° F. as before, and the pour point determined as described in Section 11.

(*c*) The upper and lower pour points shall be reported separately.

TENTATIVE METHOD OF TEST
FOR
DETECTION OF FREE SULFUR AND CORROSIVE SULFUR COMPOUNDS IN GASOLINE[1]

Serial Designation: D 130 – 27 T

This is a **Tentative Standard,** published for the purpose of eliciting criticism and suggestions, and as such is subject to annual revision.

ISSUED, 1922; REVISED, 1927.

Scope.

1. This method of test shall be used for the detection of free sulfur and corrosive sulfur compounds in gasoline.

Procedure.

2. A clean strip of mechanically polished pure sheet copper about ½ in. in width and 3 in. in length shall be placed in a suitable clean tube or sample bottle. Gasoline under test shall be added so that the copper strip is completely immersed. The test tube or sample bottle shall be closed with a loosely fitting cork and held in a suitable bath at 122° F. (50° C.).

At the end of three hours the gasoline exposed strip shall be removed and shall be compared with a similar strip of freshly polished copper.

Detection of Sulfur.

3. The presence of sulfur or corrosive sulfur compounds is indicated by the corrosion or discoloration of the gasoline exposed strip when compared with the fresh copper strip.

4. (*a*) Gasoline shall be reported as passing the test when on examination the exposed strip shows not more than extremely slight discoloration as compared with the fresh copper strip.

(*b*) Gasoline shall be reported as not passing the test when on examination the exposed strip shows more than extremely slight discoloration as compared with the fresh copper strip.

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[1] Criticisms of this Tentative Method are solicited and should be directed to Mr. R. P. Anderson, Secretary of Committee D-2 on Petroleum Products and Lubricants, 250 Park Ave., New York City.

TENTATIVE METHOD OF TEST
FOR
NEUTRALIZATION NUMBER OF PETROLEUM PRODUCTS AND LUBRICANTS[1]

Serial Designation: D 188 - 27 T

This is a **Tentative Standard,** published for the purpose of eliciting criticism and suggestions, and as such is subject to annual revision.

ISSUED, 1925; REVISED, 1926, 1927.

Scope. 1. The methods described herein are designed to indicate in petroleum products and lubricants and compounded products the presence of organic constitutents having acid characteristics and the contamination by alkalies and mineral acids.

Definitions. 2. (*a*) The Neutralization Number is the weight in milligrams of potassium hydroxide required to neutralize one gram of oil.

NOTE.—The Neutralization Number expresses the total amount of the mineral acid, and of the organic constituents having acid characteristics.

(*b*) The Alkali Neutralization Number is defined as the weight of acid required to neutralize one gram of oil, expressed in equivalent milligrams of potassium hydroxide.

(*c*) The Mineral Acid Neutralization Number is the number of milligrams of potassium hydroxide required to neutralize the mineral acid content in one gram of oil.

SOLUTIONS REQUIRED

Solutions Required. 3. (*a*) *Aqueous Potassium Hydroxide* (1 cc. = 5 mg. KOH).—Dissolve 5.1 g. of potassium hydroxide, c.p., in one liter of freshly boiled and cooled distilled water. Add a very small amount of barium hydroxide, sufficient to precipitate any potassium carbonate present. Standardize this solution against Bureau of Standards certified benzoic acid, using phenolphthalein as an indicator according to the relation:

$$\frac{5\text{ mg. KOH}}{x\text{ mg. benzoic acid}} = \frac{56.104\text{ g. KOH}}{122.048\text{ g. benzoic acid}}$$

1 cc. of KOH = 10.88 mg. benzoic acid.

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[1] Criticisms of this Tentative Method are solicited and should be directed to Mr. R. P. Anderson, Secretary of Committee D-2 on Petroleum Products and Lubricants, 250 Park Ave., New York City.

This weight of benzoic acid is required for standardization.

Make necessary adjustments so that the value of potassium hydroxide equals 5 mg. KOH per 1 cc.

NOTE.—Fit the solution bottle with a guard tube of soda lime to prevent access of carbon dioxide. The solution should be standardized at necessary intervals.

The weight of benzoic acid should be dissolved in 50 cc. of 95-per-cent alcohol and titrated cold. For blank, use same amount of alcohol and correct the titration.

(*b*) *Sulfuric Acid Solution* (1 cc. = 5 mg. KOH).—Match a sulfuric acid solution so that 1 cc. of the acid will be required to neutralize 1 cc. of the KOH, using phenolphthalein as an indicator, titrating in boiling solution.

(*c*) *Neutralized 95-per-cent Alcohol.*—Add a few drops of phenolphthalein and neutralize carefully the alcohol to a very faint pink end point with some of the above prepared alkali solution.

(*d*) *Phenolphthalein Indicator.*—Dissolve 10 g. of the indicator in 1 liter of 95-per-cent alcohol, preferably ethyl. Use 1 cc. of this strength for titration.

(*e*) *Methyl Orange Indicator.*—Dissolve 1 g. of the indicator in 1 liter of distilled water. Use 0.1 cc. of this strength for titration.

METHODS

Method A. 4. *Method A.—Neutralization Number of Petroleum Products.*

Weight of Oil: Approximately 20 g. weighed to 0.1 g.

Volume of Solvent: 100 cc. of a mixture of 1:1 neutralized alcohol and distilled water.

Procedure: Agitate oil and solvent thoroughly and heat to boiling. Add 1 cc. of phenolphthalein indicator and titrate rapidly, with vigorous agitation, to a sharp pink end point. The titration must be completed in a hot solution, reheating same if found necessary.

The color change is noted in the alcohol water layer.

Calculation:

$$\frac{\text{(Cubic centimeters of KOH)} \times 5}{\text{Weight of oil taken}} = \text{mg. KOH per 1 g. of oil.}$$

Method B. 5. *Method B.—Neutralization Number of Compounded Petroleum Products.*

Weight of Oil: Approximately 10 g. weighed to 0.1 g.

Volume of Solvent: 50 cc. of neutralized alcohol.

Procedure: Agitate oil and solvent thoroughly and heat to boiling. Add 1 cc. of phenolphthalein indicator and titrate rapidly, with vigorous agitation, to a sharp pink end point. The titration must be completed in a hot solution, reheating same if found necessary.

The color change is noted in the alcohol layer.

6. *Method C.*[1]—*Alkali or Mineral Acid Neutralization Number in Non-Compounded and Compounded Petroleum Products.* **Method C.**

Weight of Oil: 25 to 50 g. weighed to 0.1 g.

Volume of Solvent: Boiling distilled water, 200 cc.

Procedure: Introduce into a 250-cc. separatory funnel 25 to 50 g. of oil weighed to 0.1 g., and add 100 cc. of boiling distilled water. Shake vigorously, and after oil and water have separated, drain the water layer into a 500-cc. casserole. Wash the oil in the separatory funnel twice by vigorously shaking with 50-cc. portions of boiling distilled water and after separation, drain into the casserole. To the accumulated 200 cc. of water add 1 drop of 1-per-cent phenolphthalein solution. Boil. If solution turns pink, add 1 cc. of the indicator and titrate with the sulfuric acid solution until the extraction is colorless.

If the addition of 1 drop of phenolphthalein causes no change in color, add 0.1 cc. of methyl orange. If color changes to red or pink, titrate with the KOH solution until the red color is just discharged.

An equal volume of distilled water shall be titrated with the standard solution used, and the amount of alkali or acid required shall be subtracted from the titration for blank correction.

Calculation: If the acid solution was required to discharge the phenolphthalein end point, the alkali neutralization number equals:

$$\frac{(\text{Cubic centimeters of acid}) \times 5}{\text{Weight of oil}}$$

If the alkali solution was required to discharge the methyl orange end point, the mineral acid neutralization number equals:

$$\frac{(\text{Cubic centimeters of alkali}) \times 5}{\text{Weight of oil}}$$

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[1] When the oil is acid, the acidity shall not be reported as sulfuric or hydrochloric acid unless the presence of these acids shall have been confirmed by tests.

TENTATIVE METHOD OF TEST
FOR
PENETRATION OF GREASES AND PETROLATUM[1]

Serial Designation: D 217 – 27 T

This is a **Tentative Standard,** published for the purpose of eliciting criticism and suggestions, and as such is subject to annual revision.

ISSUED, 1925; REVISED, 1926, 1927.

Interpretation of Results.

It should be understood that the original consistency of grease is determined by a variety of factors which are very difficult to control. The soap content is the most important single factor, but the kind of fats used, the method of mixing, the final water content, and the temperature of pouring are all very important in determining the final consistency, so that it is impracticable to maintain these consistencies within narrow limits. Any working of the sample after it is poured, or any remelting, will greatly change the consistency. The original consistency also changes to some extent on standing, changing most rapidly during the first 48 hours after manufacture and more slowly thereafter.

Although most tests in the past have been based on the original consistency of greases, this consistency bears no necessary relationship to the worked consistency which is the factor of practical importance for most uses of cup greases, etc. Tests on such greases should therefore be made on the worked consistency. It is also almost impossible to measure the unworked consistency when samples have to be taken from barrels or other large containers.

On the other hand, for very hard greases, such as railroad greases used in slab form, the original or unworked consistency is generally the property of practical importance and should be the object of the test.

Scope.

1. This method shall be used to measure the original consistency or the worked consistency of No. 0 cup grease and all harder greases and of petrolatum (unworked).

2. The method shall not be applied to greases which have been melted after having been poured and cooled during manufacture. Petrolatum, however, should be melted, poured into a suitable container and cooled before testing.

APPARATUS

Penetrometer.

3. The penetration shall be measured on what is customarily known as an asphalt penetrometer such as that described in the *Proceedings* of the American Society for Testing Materials, Vol. VII,

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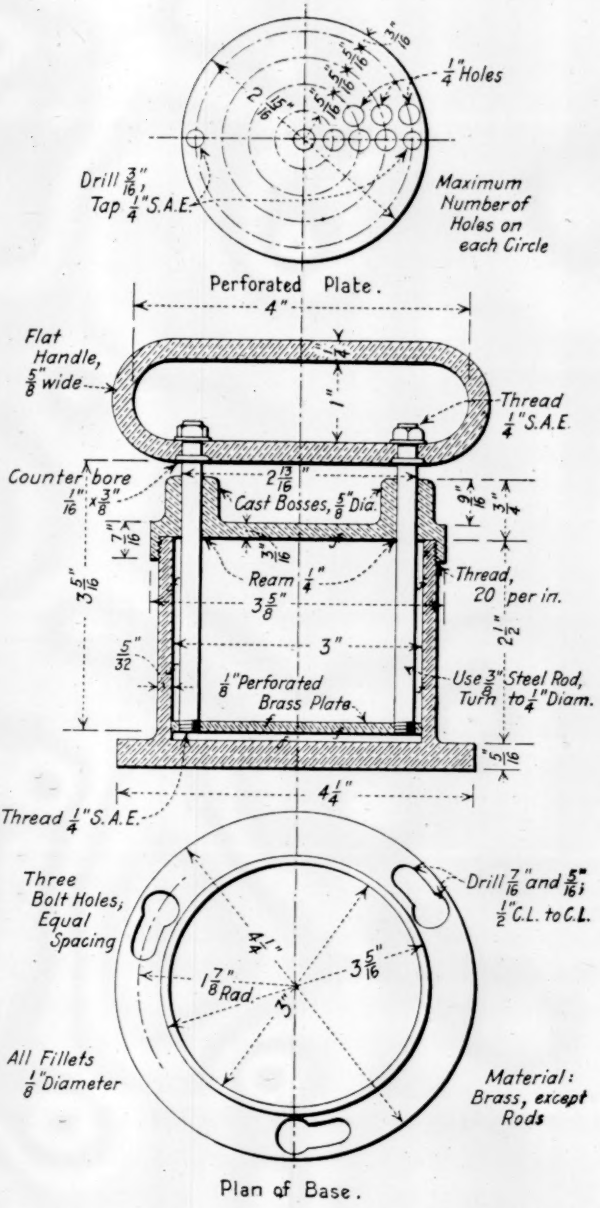
[1] Criticisms of this Tentative Method are solicited and should be directed to Mr. R. P. Anderson, Secretary of Committee D-2 on Petroleum Products and Lubricants. 250 Park Ave., New York City.


$\frac{3}{16}$
$\frac{5}{16}$
$\frac{5}{16}$
$\frac{5}{16}$
$\frac{5}{16}$
2
$\frac{1}{4}$" Holes
Drill $\frac{3}{16}$",
Tap $\frac{1}{4}$" S.A.E.
Maximum
Number of
Holes on
each Circle
4"
Flat
Handle,
$\frac{5}{8}$" wide
$\frac{1}{4}$"
1"
Thread
$\frac{1}{4}$" S.A.E.
Counter bore
$\frac{1}{16}$" × $\frac{3}{8}$"
$2\frac{13}{16}$"
Cast Bosses, $\frac{5}{8}$" Dia.
$\frac{9}{16}$"
$\frac{3}{4}$"
$\frac{7}{16}$"
$\frac{3}{16}$"
Ream $\frac{1}{4}$"
Thread,
20 per in.
$3\frac{5}{16}$"
$3\frac{5}{8}$"
$2\frac{1}{2}$"
3"
$\frac{5}{32}$"
$\frac{1}{8}$" Perforated
Brass Plate
Use $\frac{3}{8}$" Steel Rod,
Turn to $\frac{1}{4}$" Diam.
$\frac{5}{16}$"
$4\frac{1}{4}$"
Thread $\frac{1}{4}$" S.A.E.
Three
Bolt Holes,
Equal
Spacing
Drill $\frac{7}{16}$" and $\frac{5}{16}$";
$\frac{1}{2}$" C.L. to C.L.
$4\frac{1}{4}$"
$1\frac{7}{8}$" Rad.
$3\frac{5}{16}$"
3"
All Fillets
$\frac{1}{8}$" Diameter
Material:
Brass, except
Rods

Perforated Plate.

Plan of Base.

FIG. 1.—Grease Worker.

p. 626 (1907), and illustrated in Fig. 3 herein. It is desirable, however, to modify this penetrometer by placing a flat metal plate or transite board on top of the present grid base to give a flat support for the container. If many tests are to be made, it is preferable to replace the ordinary grid base with a special flat base 6 in. in diameter.

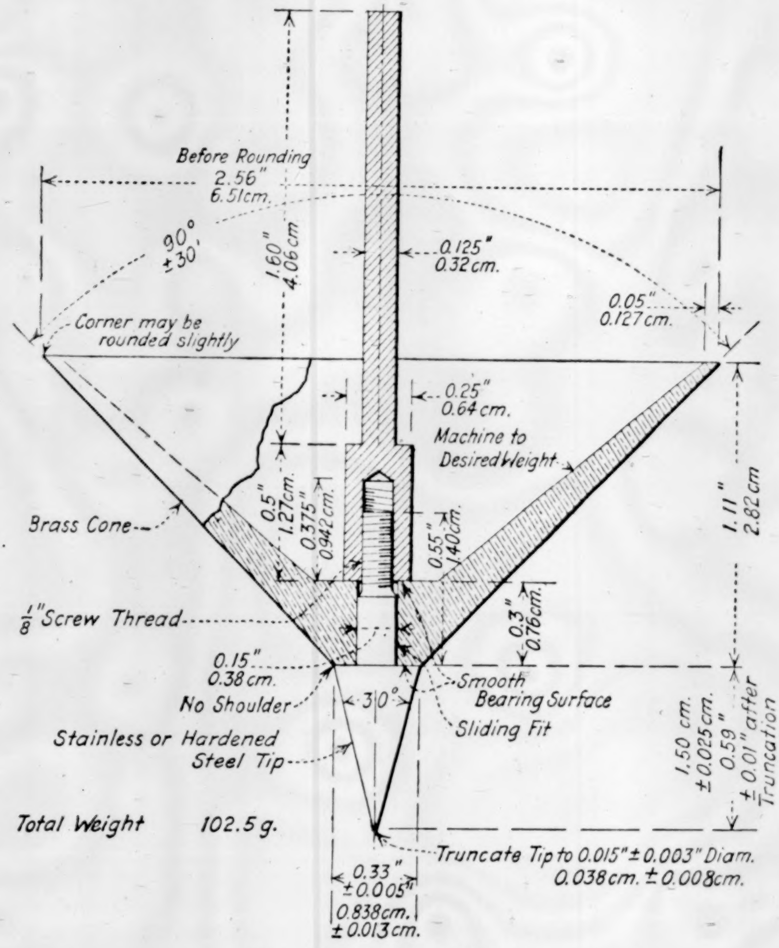

Before Rounding
2.56"
6.51cm.
90°
±30'
1.60"
4.06 cm
0.125"
0.32 cm.
0.05"
0.127 cm.
Corner may be rounded slightly
0.25"
0.64 cm.
Machine to Desired Weight
Brass Cone
0.5"
1.27cm.
0.375"
0.942 cm.
0.55"
1.40 cm.
1.11"
2.82 cm
1/8" Screw Thread
0.3"
0.76 cm.
0.15"
0.38 cm.
No Shoulder
30°
Smooth Bearing Surface
Sliding Fit
Stainless or Hardened Steel Tip
1.50 cm.
±0.025 cm.
0.59"
±0.01" after Truncation
Total Weight 102.5 g.
Truncate Tip to 0.015" ± 0.003" Diam.
0.038 cm. ± 0.008 cm.
0.33"
±0.005"
0.838 cm.
±0.013 cm.

FIG. 2.—Penetrometer Cone.

This plate should have a cork insert in the center to prevent dulling the tip of the cone if it should drop.

Cone and Plunger. 4. The needle used in the asphalt penetration tests shall be replaced with the cone shown in Fig. 2.[1] The cone shall be constructed of stainless steel or of brass with a detachable hardened steel or stainless steel tip and made in accordance with the outside dimensions and tolerances shown. The interior construction and dimensions without tolerances are intended to be suggestive only. The outside surface of the cone and tip shall be given a very smooth finish.

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[1] The cone may be combined with the asphalt plunger if desired, providing the total weight of cone and plunger and the outside dimensions of the cone are not thereby changed.

Weight. 5. The total moving weight in the test shall be 150 g. If the asphalt plunger weighs 47.5 g. (50 g. − 2.5 g. needle) the cone or the cone plus an attached weight must weigh 102.5 g. It is in general desirable to make the cone as light as possible so that it will have a wide range of usefulness, and to add a weight to give the desired total for the grease test. If the conditions of the tests are not specified, the penetration of a grease shall be understood to refer to the results of this test made at 77° F. (25° C.).

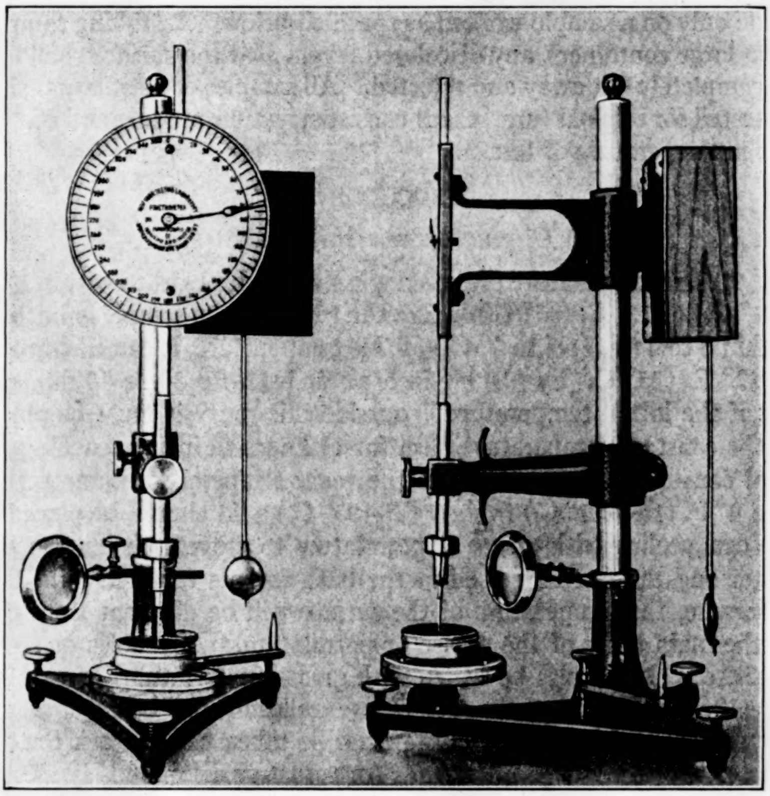

FIG. 3.—Penetrometer.

Grease Worker. 6. The grease worker shown in Fig. 1 shall be used to work the grease to constant consistency in tests where the worked consistency is to be measured.

Constant Temperature Bath. 7. A constant temperature bath regulated to 77° F. ±1° F. (25° C. ±0.5° C.) is desirable to bring the samples to the temperature of test if many tests are to be made.

SAMPLES

Samples for Tests. 8. Tests on the unworked consistency of grease shall be made only on grease in the original container (or cake in the case of very hard greases), 1-lb. tins being especially convenient for the purpose. If samples are to be taken from large containers, the tests must be made only on a sample worked as specified below. In taking samples from large containers, any discolored layers near the surface shall first be completely cut away and rejected. All samples of petrolatum shall be tested for original (unworked) consistency after melting and cooling to the temperature of test.

PROCEDURE

(A) *Original (Unworked) Consistency*

Bringing to Temperature of Test. 9. The temperature of the sample shall be brought to within 1° F. (0.5° C.) of 77° F. (25° C.) before the test. If the sample is initially within 3 to 4° F. (1.5 to 2° C.) of this temperature, it can be brought to 77° F. (25° C.) by placing in a water bath for 30 or 40 minutes, but if the initial temperature is outside this range it must be placed in the constant temperature bath for 1½ hours to insure reaching the final constant temperature. If the room temperature is more than 3 to 4° F. (1.5 to 2° C.) from 77° F. (25° C.) a lid should be placed on the can, sealing with grease or petrolatum to prevent the entrance of water and the can immersed in the bath for the required period as, otherwise, the temperature of the surface will be different from that of the main body of the grease or petrolatum. Any holes or seams in the can should also be sealed with grease (petrolatum) or paraffin.

Preparation of Sample. 10. The surface of the grease or petrolatum shall be cut level and very smooth with a knife. Care must be taken not to work the surface of the grease or petrolatum. Any crust or discolored layers shall be completely removed before testing.

Procedure. 11. The can of grease or petrolatum shall be placed on the penetrometer table and the cone lowered until the tip just touches the surface. Watching the shadow of the tip aids in accurately setting the cone. The scale shall then be set to zero and the plunger released suddenly and kept released for five seconds. The penetration is read from the scale (the units being tenths of a millimeter) by the same procedure as is customary in measuring asphalt penetration as described in the Standard Method of Test for Penetration of Bituminous

Materials (Serial Designation: D 5) of the American Society for Testing Materials.[1]

Spacing of Tests in Cans.

12. In making tests, the total surface area disturbed by the test has a diameter about equal to the measured depth of penetration. In order to prevent one test from being affected by another disturbed area or by sides of the can, in starting a test the tip shall never be placed closer to the sides of the can or the edge of a previous hole than the penetration distance of that particular grease or petrolatum. The grease or petrolatum shall not be smoothed over for further tests.

Number of Tests Required.

13. Five tests shall be made on each sample and the average reported as the consistency, if the mean deviation of these readings does not exceed 3.0 per cent. If the mean deviation does exceed 3.0 per cent, the average of ten readings shall be reported as the consistency of the sample. More than one 1-lb. can will be needed for the required number of tests on the softer greases or petrolatums.

(*B*) *Procedure for Worked Consistency*

Procedure for Worked Consistency.

14. The procedure for worked greases shall be the same as that for unworked consistency except that the grease to be tested shall be transferred to the worker, which shall be filled heaping full with a minimum inclusion of air, brought to within 2° F. (1° C.) of 75° F. (24° C.) and worked with 60 double strokes of the plunger.[2] The top and plunger can then be removed, the surface smoothed over and the test made at once, if the temperature is within 1° F. (0.5° C.) of 77° F. (25° C.). As soon as one test is made, the surface may be smoothed over for the next, taking care to avoid creating air pockets. If desired, the grease may be transferred carefully to another container before bringing to 77° F. (25° C.) and testing. One 1-lb. sample is sufficient for all tests.

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[1] 1927 Book of A.S.T.M. Standards, Part II.

[2] In general quite similar results may be obtained by working the grease thoroughly for five minutes with a spatula on a flat plate, providing care is taken to prevent working in much air. For referee tests, however, the standard worker must be used.

TENTATIVE SPECIFICATIONS
FOR
HIGH-CARBON TAR FOR SURFACE TREATMENT, COLD APPLICATION.[1]

Serial Designation: D 104 – 27 T

This is a **Tentative Standard,** published for the purpose of eliciting criticism and suggestions, and as such is subject to annual revision.

ISSUED, 1921; REVISED, 1923, 1927.

Properties. 1. The tar shall conform to the following requirements:

(*a*) Water........................not more than 2.00 per cent

(*b*) Specific viscosity, Engler,[2] 50 cc. at 40° C. (104° F.)..8 to 35

(*c*) Distillation test on water-free material:

Total Distillate, by weight, 0 to 170° C. (32 to 338° F.)	not more than 7.00	per cent
Total Distillate, by weight, 0 to 235° C. (32 to 455° F.)	not more than 20.00	"
Total Distillate, by weight, 0 to 270° C. (32 to 518° F.)	not more than 30.00	"
Total Distillate, by weight, 0 to 300° C. (32 to 572° F.)	not more than 35.00	"
Residue, by weight	not less than 65.00	"

(*d*) Specific gravity at 25° C. (77° F.) of total distillate to 300° C. (572° F.)...................................not less than 1.01

(*e*) Softening point (Ring-and-Ball Method) of residue from distillation test........................not more than 60° C. (140° F.)

(*f*) Total Bitumen (Soluble in Carbon Disulfide)..............
..................................88 to 97 per cent

Methods of Testing. 2. The properties enumerated in these specifications shall be determined in accordance with the following methods of test of the American Society for Testing Materials, except as specified in Paragraph (*b*):

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[1] Criticisms of these Tentative Specifications are solicited and should be directed to Mr. Prévost Hubbard, Secretary of Committee D-4 on Road and Paving Materials, 441 Lexington Ave., New York City.

[2] Within the viscosity limits designated a material should be chosen to meet the local conditions of temperature, road conditions and climate. It is recommended that materials be called for under the following range and headings: Light 8–13, Medium 13–18, Heavy 18–25, Extra Heavy 25–35.

(*a*) *Percentage of Water:* Standard Method of Test for Water in Petroleum Products and Other Bituminous Materials (Serial Designation: D 95);[1]

(*b*) *Specific Viscosity:*[2] Method contained in *Bulletin No. 691*, U. S. Department of Agriculture, the instrument being standardized by the Bureau of Standards. The results shall be reported as specific viscosity compared with water at 25° C. (77° F.).

(*c*) *Distillation:* Tentative Method of Test for Distillation of Bituminous Materials Suitable for Road Treatment (Serial Designation: D 20 - 27 T);[3]

(*d*) *Softening Point:* Standard Method of Test for Softening Point of Bituminous Materials (Ring-and-Ball Method) (Serial Designation: D 36);[1]

(*e*) *Total Bitumen:* Standard Method of Test for the Determination of Bitumen (Serial Designation: D 4).[1]

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[1] 1927 Book of A.S.T.M. Standards, Part II.

[2] The Engler test has not been standardized by the American Society for Testing Materials. Committees of the Society have under consideration the Saybolt Furol Apparatus, which may be adopted later.

[3] See p. 954.

TENTATIVE SPECIFICATIONS
FOR
LOW-CARBON TAR FOR SURFACE TREATMENT, COLD APPLICATION[1]

Serial Designation: D 105 – 27 T

This is a **Tentative Standard,** published for the purpose of eliciting criticism and suggestions, and as such is subject to annual revision.

Issued, 1921; Revised, 1923, 1927.

Properties. 1. The tar shall conform to the following requirements:

(*a*) Water........................not more than 2.00 per cent

(*b*) Specific viscosity, Engler,[2] 50 cc. at 40° C. (104° F.)...8 to 35

(*c*) Distillation test on water-free material:

Total Distillate, by weight, 0 to 170° C. (32 to 338° F.)....................	not more than 5.00	per cent
Total Distillate, by weight, 0 to 235° C. (32 to 455° F.)....................	not more than 20.00	"
Total Distillate, by weight, 0 to 270° C. (32 to 518° F.)....................	not more than 35.00	"
Total Distillate, by weight, 0 to 300° C. (32 to 572° F.)....................	not more than 45.00	"
Residue, by weight....................	not less than 55.00	"

(*d*) Softening point (Ring-and-Ball Method) of residue from distillation test........................not more than 60° C. (140° F.)

(*e*) Total Bitumen (Soluble in Carbon Disulfide).............. ....not less than 95.00 per cent

Methods of Testing. 2. The properties enumerated in these specifications shall be determined in accordance with the following methods of test of the American Society for Testing Materials, except as specified in Paragraph (*b*):

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[1] Criticisms of these Tentative Specifications are solicited and should be directed to Mr. Prévost Hubbard, Secretary of Committee D-4 on Road and Paving Materials, 441 Lexington Ave., New York City.

[2] Within the viscosity limits designated a material should be chosen to meet the local conditions of temperature, road conditions and climate. It is recommended that materials be called for under the following range and headings: Light 8–13, Medium 13–18, Heavy 18–25, Extra Heavy 25–35.

(*a*) *Percentage of Water:* Standard Method of Test for Water in Petroleum Products and Other Bituminous Materials (Serial Designation: D 95);[1]

(*b*) *Specific Viscosity:*[2] Method contained in ***Bulletin No. 691***, U. S. Department of Agriculture, the instrument being standardized by the Bureau of Standards. The results shall be reported as specific viscosity compared with water at 25° C. (77° F.).

(*c*) *Distillation:* Tentative Method of Test for Distillation of Bituminous Materials Suitable for Road Treatment (Serial Designation: D 20 - 27 T);[3]

(*d*) *Softening Point:* Standard Method of Test for Softening Point of Bituminous Materials (Ring-and-Ball Method) (Serial Designation: D 36);[1]

(*e*) *Total Bitumen:* Standard Method of Test for the Determination of Bitumen (Serial Designation: D 4).[1]

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[1] 1927 Book of A.S.T.M. Standards, Part II.

[2] The Engler test has not been standardized by the American Society for Testing Materials. Committees of the Society have under consideration the Saybolt Furol apparatus, which may be adopted later.

[3] See p. 954.

TENTATIVE SPECIFICATIONS

FOR

HIGH-CARBON TAR CEMENT FOR USE COLD IN REPAIR WORK (CUT-BACK PRODUCT).[1]

Serial Designation: D 106 - 27 T

This is a **Tentative Standard,** published for the purpose of eliciting criticism and suggestions, and as such is subject to annual revision.

ISSUED, 1921; REVISED, 1923, 1925, 1927.

Properties. 1. The tar cement shall conform to the following requirements:

(*a*) Water........................not more than 2.00 per cent

(*b*) Specific viscosity, Engler,[2] 50 cc. at 40° C. (104° F.)..35 to 80

(*c*) Distillation test on water-free material:

Total Distillate, by weight, 0 to 170° C. (32 to 338° F.)....................	2.00 to 8.00 per cent
Total Distillate, by weight, 0 to 235° C. (32 to 455° F.)....................	8.00 to 20.00 "
Total Distillate, by weight, 0 to 270° C. (32 to 518° F.)....................	18.00 to 30.00 "
Total Distillate, by weight, 0 to 300° C. (32 to 572° F.)....................	not more than 35.00 "
Residue, by weight....................	not less than 65.00 "

(*d*) Softening point (Ring-and-Ball Method) of residue from distillation test........................not more than 65° C. (149° F.)

(*e*) Total Bitumen (Soluble in Carbon Disulfide)[3]..78 to 95 per cent

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[1] Criticisms of these Tentative Specifications are solicited and should be directed to Mr. Prévost Hubbard, Secretary of Committee D-4 on Road and Paving Materials, 441 Lexington Ave., New York City.

[2] **It is recommended that materials be called for under the following range and headings: Light 35 to 60, Heavy 60 to 80. The heavy material may require heating before use and care should be taken to avoid foaming on account of the possible water content.**

[3] **The specification range for total bitumen covers a wide variety of materials. If products from vertical retort or low-carbon coke-oven tars are desired, a range of 88 to 95 per cent should be specified. If high-carbon coke-oven or mixtures of coke-oven and gas-house tars are desired, a range of 78 to 88 per cent should be specified.**

Methods of Testing.

2. The properties enumerated in these specifications shall be determined in accordance with the following methods of test of the American Society for Testing Materials, except as specified in Paragraph (*b*):

(*a*) *Percentage of Water:* Standard Method of Test for Water in Petroleum Products and Other Bituminous Materials (Serial Designation: D 95);[1]

(*b*) *Specific Viscosity:*[2] Method contained in *Bulletin No. 691*, U. S. Department of Agriculture, the instrument being standardized by the Bureau of Standards. The results shall be reported as specific viscosity compared with water at 25° C. (77° F.).

(*c*) *Distillation:* Tentative Method of Test for Distillation of Bituminous Materials Suitable for Road Treatment (Serial Designation: D 20 - 27 T);[3]

(*d*) *Softening Point:* Standard Method of Test for Softening Point of Bituminous Materials (Ring-and-Ball Method) (Serial Designation: D 36);[1]

(*e*) *Total Bitumen:* Standard Method of Test for the Determination of Bitumen (Serial Designation: D 4).[1]

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[1] 1927 Book of A.S.T.M. Standards, Part II.

[2] The Engler test has not been standardized by the American Society for Testing Materials. Committees of the Society have under consideration the Saybolt Furol apparatus, which may be adopted later.

[3] See p. 954.

TENTATIVE SPECIFICATIONS

FOR

LOW-CARBON TAR CEMENT FOR USE COLD IN REPAIR WORK (CUT-BACK PRODUCT).[1]

Serial Designation: D 107 - 27 T

This is a **Tentative Standard,** published for the purpose of eliciting criticism and suggestions, and as such is subject to annual revision.

ISSUED, 1921; REVISED, 1923, 1927.

Properties. 1. The tar cement shall conform to the following requirements:

(*a*) Water......................not more than 2.00 per cent

(*b*) Specific viscosity, Engler,[2] 50 cc. at 40° C. (104° F.)..35 to 80

(*c*) Distillation test on water-free material:

Total Distillate, by weight, 0 to 170° C. (32 to 338° F.)...................	3.00 to 10.00	per cent.
Total Distillate, by weight, 0 to 235° C. (32 to 455° F.)...................	8.00 to 20.00	"
Total Distillate, by weight, 0 to 270° C. (32 to 518° F.)...................	18.00 to 30.00	"
Total Distillate, by weight, 0 to 300° C. (32 to 572° F.)...................	not more than 38.00	"
Residue, by weight...................	not less than 62.00	"

(*d*) Softening point (Ring-and-Ball Method) of residue from distillation test......................not more than 65° C. (149° F.)

(*e*) Total Bitumen (Soluble in Carbon Disulfide)..not less than 95 per cent

Methods of Testing. 2. The properties enumerated in these specifications shall be determined in accordance with the following methods of test of the American Society for Testing Materials, except as specified in Paragraph (*b*):

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[1] Criticisms of these Tentative Specifications are solicited and should be directed to Mr. Prévost Hubbard, Secretary of Committee D-4 on Road and Paving Materials, 441 Lexington Ave., New York City.

[2] It is recommended that materials be called for under the following range and headings: Light 35 to 60, Heavy 60 to 80. The heavy material may require heating before use and care should be taken to avoid foaming on account of the possible water content.

(*a*) *Percentage of Water:* Standard Method of Test for Water in Petroleum Products and Other Bituminous Materials (Serial Designation: D 95);[1]

(*b*) *Specific Viscosity:*[2] Method contained in *Bulletin No. 691*, U. S. Department of Agriculture, the instrument being standardized by the Bureau of Standards. The results shall be reported as specific viscosity compared with water at 25° C. (77° F.).

(*c*) *Distillation:* Tentative Method of Test for Distillation of Bituminous Materials Suitable for Road Treatment (Serial Designation: D 20 - 27 T);[3]

(*d*) *Softening Point:* Standard Method of Test for Softening Point of Bituminous Materials (Ring-and-Ball Method) (Serial Designation: D 36);[1]

(*e*) *Total Bitumen:* Standard Method of Test for the Determination of Bitumen (Serial Designation: D 4).[1]

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[1] 1927 Book of A.S.T.M. Standards, Part II.

[2] The Engler test has not been standardized by the American Society for Testing Materials. Committees of the Society have under consideration the Saybolt Furol apparatus, which may be adopted later.

[3] See p. 954.

TENTATIVE SPECIFICATIONS
FOR
HIGH-CARBON TAR FOR SURFACE TREATMENT, HOT APPLICATION.[1]

Serial Designation: D 108 – 27 T

This is a **Tentative Standard,** published for the purpose of eliciting criticism and suggestions, and as such is subject to annual revision.

Issued, 1921; Revised, 1923, 1927.

Properties. 1. The tar shall conform to the following requirements:

(*a*) Water .... 0.00 per cent

(*b*) Float test at 32° C. (89.6° F.) .... 60 to 150 sec.

(*c*) Distillation test:

Total Distillate, by weight, 0 to 170° C. (32 to 338° F.)	not more than 1.00 per cent
Total Distillate, by weight, 0 to 235° C. (32 to 455° F.)	not more than 10.00 "
Total Distillate, by weight, 0 to 270° C. (32 to 518° F.)	not more than 15.00 "
Total Distillate, by weight, 0 to 300° C. (32 to 572° F.)	not more than 25.00 "
Residue, by weight	not less than 75.00 "

(*d*) Specific gravity at 38° C. (100.4° F.) of total distillate to 300° C. (572° F.)...................................not less than 1.02

(*e*) Softening point (Ring-and-Ball Method) of residue from distillation test.........................not more than 65° C. (149° F.)

(*f*) Total Bitumen (Soluble in Carbon Disulfide)[2]..78 to 95 per cent

Methods of Testing. 2. The properties enumerated in these specifications shall be determined in accordance with the following methods of test of the American Society for Testing Materials:

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[1] Criticisms of these Tentative Specifications are solicited and should be directed to Mr. Prévost Hubbard, Secretary of Committee D-4 on Road and Paving Materials, 441 Lexington Ave., New York City.

[2] The specification range for total bitumen covers a wide variety of materials. If products from vertical retort or low-carbon coke-oven tars are desired, a range of 88 to 95 per cent should be specified. If high-carbon coke-oven or mixtures of coke-oven and gas-house tars are desired, a range of 78 to 88 per cent should be specified.

(*a*) *Percentage of Water:* Standard Method of Test for Water in Petroleum Products and Other Bituminous Materials (Serial Designation: D 95);[1]

(*b*) *Float Test:* Standard Method of Float Test for Bituminous Materials (Serial Designation: D 139);[1]

(*c*) *Distillation:* Tentative Method of Test for Distillation of Bituminous Materials Suitable for Road Treatment (Serial Designation: D 20 - 27 T);[2]

(*d*) *Softening Point:* Standard Method of Test for Softening Point of Bituminous Materials (Ring-and-Ball Method) (Serial Designation: D 36);[1]

(*e*) *Total Bitumen:* Standard Method of Test for the Determination of Bitumen (Serial Designation: D 4).[1]

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[1] 1927 Book of A.S.T.M. Standards, Part II.

[2] See p. 954.

TENTATIVE SPECIFICATIONS
FOR
LOW-CARBON TAR FOR SURFACE TREATMENT, HOT APPLICATION.[1]

Serial Designation: D 109 - 27 T

This is a **Tentative Standard,** published for the purpose of eliciting criticism and suggestions, and as such is subject to annual revision.

ISSUED, 1921; REVISED, 1923, 1927.

Properties. 1. The tar shall conform to the following requirements:

(*a*) Water....................................0.00 per cent

(*b*) Float test at 32° C. (89.6° F.)..................60 to 150 sec.

(*c*) Distillation test:

Total Distillate, by weight, 0 to 170° C. (32 to 338° F.)	not more than	1.00	per cent
Total Distillate, by weight, 0 to 235° C. (32 to 455° F.)	not more than	4.00	"
Total Distillate, by weight, 0 to 270° C. (32 to 518° F.)	not more than	13.00	"
Total Distillate, by weight, 0 to 300° C. (32 to 572° F.)	not more than	26.00	"
Residue, by weight	not less than	74.00	"

(*d*) Softening point (Ring-and-Ball Method) of residue from distillation test........................not more than 65° C. (149° F.)

(*e*) Total Bitumen (Soluble in Carbon Disulfide)...not less than 95 per cent

Methods of Testing. 2. The properties enumerated in these specifications shall be determined in accordance with the following methods of test of the American Society for Testing Materials:

(*a*) *Percentage of Water:* Standard Method of Test for Water in Petroleum Products and Other Bituminous Materials (Serial Designation: D 95);[2]

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[1] Criticisms of these Tentative Specifications are solicited and should be directed to Mr. Prévost Hubbard, Secretary of Committee D-4 on Road and Paving Materials, 441 Lexington Ave., New York City.

[2] 1927 Book of A.S.T.M. Standards, Part II.

(*b*) *Float Test:* Standard Method of Float Test for Bituminous Materials (Serial Designation: D 139);[1]

(*c*) *Distillation:* Tentative Method of Test for Distillation of Bituminous Materials Suitable for Road Treatment (Serial Designation: D 20 – 27 T);[2]

(*d*) *Softening Point:* Standard Method of Test for Softening Point of Bituminous Materials (Ring-and-Ball Method) (Serial Designation: D 36);[1]

(*e*) *Total Bitumen:* Standard Method of Test for the Determination of Bitumen (Serial Designation: D 4).[1]

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[1] 1927 Book of A.S.T.M. Standards, Part II.

[2] See p. 954.

TENTATIVE SPECIFICATIONS
FOR
HIGH-CARBON TAR CEMENT.[1]

Serial Designation: D 110 – 27 T

This is a **Tentative Standard,** published for the purpose of eliciting criticism and suggestions, and as such is subject to annual revision.

ISSUED, 1921; REVISED, 1923, 1925, 1927.

Scope. 1. These specifications cover material suitable for use in the construction of tar macadam and tar concrete pavements.

Properties. 2. The tar cement shall conform to the following requirements:

(*a*) Water.................................0.00 per cent

(*b*) Softening point[2] (Ring-and-Ball Method).....................................30 to 40° C. (86 to 104° F.)[3]

(*c*) Distillation test:

Total Distillate, by weight, 0 to 170° C. (32 to 338° F.)	not more than 1.00	per cent
Total Distillate, by weight, 0 to 270° C. (32 to 518° F.)	not more than 10.00	"
Total Distillate, by weight, 0 to 300° C. (32 to 572° F.)	not more than 20.00	"
Residue, by weight	not less than 80.00	"

(*d*) Specific gravity at 38° C. (100.4° F.) of total distillate to 300° C. (572° F.)..............................not less than 1.02

(*e*) Softening point (Ring-and-Ball Method) of residue from distillation test.......................not more than 65° C. (149° F.)

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[1] Criticisms of these Tentative Specifications are solicited and should be directed to Mr. Prévost Hubbard, Secretary of Committee D-4 on Road and Paving Materials, 441 Lexington Ave., New York City.

[2] If desired, a float test may be substituted for the softening point test, in which case the requirements shall be as follows: Float Test at 50° C. (122° F.), 100 to 220 sec

[3] The specification range for softening point, within the above limits, should be 5° C. for any given locality, for example, 30 to 35° C. for cold climates, equivalent to a float test at 50° C. of 100 to 160 sec.; 35 to 40° C. for warm climates, equivalent to a float test at 50° C. of 160 to 220 sec.

(*f*) **Total Bitumen (Soluble in Carbon Disulfide)**[1] .... 78 to 95 per cent

Methods of Testing.

3. The properties enumerated in these specifications shall be determined in accordance with the following methods of test of the American Society for Testing Materials:

(*a*) *Percentage of Water:* Standard Method of Test for Water in Petroleum Products and Other Bituminous Materials (Serial Designation: D 95);[2]

(*b*) *Softening Point:* Standard Method of Test for Softening Point of Bituminous Materials (Ring-and-Ball Method) (Serial Designation: D 36);[2]

(*c*) *Distillation:* Tentative Method of Test for Distillation of Bituminous Materials Suitable for Road Treatment (Serial Designation: D 20 - 27 T);[3]

(*d*) *Float Test:* Standard Method of Float Test for Bituminous Materials (Serial Designation: D 139);[2]

(*e*) *Total Bitumen:* Standard Method of Test for the Determination of Bitumen (Serial Designation: D 4).[2]

---

[1] The specification range for total bitumen covers a wide variety of materials. If products from vertical retort or low-carbon coke-oven tars are desired, a range of 88 to 95 per cent should be specified. If high-carbon coke-oven or mixtures of coke-oven and gas-house tars are desired, a range of 78 to 88 per cent should be specified.

[2] 1927 Book of A.S.T.M. Standards, Part II.

[3] See p. 954.

TENTATIVE SPECIFICATIONS
FOR
LOW-CARBON TAR CEMENT[1]

Serial Designation: D 111 – 27 T

This is a **Tentative Standard,** published for the purpose of eliciting criticism and suggestions, and as such is subject to annual revision.

ISSUED, 1921; REVISED, 1923, 1927.

Scope. 1. These specifications cover material suitable for use in the construction of tar macadam and tar concrete pavements.

Properties. 2. The tar cement shall conform to the following requirements:

(*a*) Water..0.00 per cent

(*b*) Softening point[2] (Ring-and-Ball Method)..30 to 40° C. (86 to 104° F.)[3]

(*c*) Distillation test:

Total Distillate, by weight, 0 to 170° C. (32 to 338° F.)	not more than	1.00	per cent
Total Distillate, by weight, 0 to 235° C. (32 to 455° F.)	not more than	2.00	"
Total Distillate, by weight, 0 to 270° C. (32 to 518° F.)	not more than	10.00	"
Total Distillate, by weight, 0 to 300° C. (32 to 572° F.)	not more than	20.00	"
Residue, by weight	not less than	80.00	"

(*d*) Softening point (Ring-and-Ball Method) of residue from distillation test........................not more than 65° C. (149° F.)

(*e*) Total Bitumen (Soluble in Carbon Disulfide)..not less than 95 per cent

Methods of Testing. 3. The properties enumerated in these specifications shall be determined in accordance with the following methods of test of the American Society for Testing Materials:

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[1] Criticisms of these Tentative Specifications are solicited and should be directed to Mr. Prévost Hubbard, Secretary of Committee D-4 on Road and Paving Materials, 441 Lexington Ave., New York City.

[2] If desired, a float test may be substituted for the softening point test, in which case the requirements shall be as follows: Float Test at 50° C. (122° F.), 100 to 220 sec.

[3] The specification range for softening point, within the above limits, should be 5° C. for any given locality, for example, 30 to 35° C. for cold climates, equivalent to a float test at 50° C. of 100 to 160 sec.; 35 to 40° C. for warm climates, equivalent to a float test at 50° C. of 160 to 220 sec.

(*a*) *Percentage of Water:* Standard Method of Test for Water in Petroleum Products and Other Bituminous Materials (Serial Designation: D 95);[1]

(*b*) *Softening Point:* Standard Method of Test for Softening Point of Bituminous Materials (Ring-and-Ball Method) (Serial Designation: D 36);[1]

(*c*) *Distillation:* Tentative Method of Test for Distillation of Bituminous Materials Suitable for Road Treatment (Serial Designation: D 20 - 27 T);[2]

(*d*) *Float Test:* Standard Method of Float Test for Bituminous Materials (Serial Designation: D 139);[1]

(*e*) *Total Bitumen:* Standard Method of Test for the Determination of Bitumen (Serial Designation: D 4).[1]

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[1] 1927 Book of A.S.T.M. Standards, Part II.

[2] See p. 954.

TENTATIVE SPECIFICATIONS

FOR

COAL-TAR PITCH FOR STONE BLOCK FILLER[1]

Serial Designation: D 112 - 27 T

This is a **Tentative Standard,** published for the purpose of eliciting criticism and suggestions, and as such is subject to annual revision.

ISSUED, 1921; REVISED, 1922, 1923, 1927.

Properties. 1. The coal-tar pitch shall conform to the following requirements:

(*a*) Water .... 0.00 per cent

(*b*) Softening point[2] (Cube-in-Water Method) .... 46 to 57° C. (115 to 135° F.)

(*c*) Distillation test:

Total Distillate, by weight, 0 to 300° C.
(32 to 572° F.) .... not more than 14.00 per cent.
Residue, by weight .... not less than 86.00 "

(*d*) Specific gravity at 38° C. (100.4° F.) of total distillate to 300° C. (572° F.) .... not less than 1.02

(*e*) Softening point (Cube-in-Water Method) of residue from distillation test .... not more than 75° C. (167° F.)

(*f*) Ductility at 50 to 100 penetration, at 25° C. (77° F.) .... not less than 50 cm.

NOTE.—The penetration of the pitch shall be brought within the range of 50 to 100 penetration by heating in an open vessel with frequent stirrings at a temperature of not over 350° F.

(*g*) Total Bitumen (Soluble in Carbon Disulfide) .... 65.00 to 80.00 per cent.

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[1] Criticisms of these Tentative Specifications are solicited and should be directed to Mr. Prévost Hubbard, Secretary of Committee D-4 on Road and Paving Materials, 441 Lexington Ave., New York City.

[2] The Softening Point (Cube-in-Water Method) specified should have a range of not over 10° F. within the above limits. The range, within the limits of 115 to 135° F. should vary with the use of the material, for example, if used in admixture with sand, in a northern locality or a southern locality. The softening point range, within the above limits, should also vary according to the character of the paving.

Methods of Testing.

2. The properties enumerated in these specifications shall be determined in accordance with the following methods of test of the American Society for Testing Materials:

(*a*) *Percentage of Water:* Standard Method of Test for Water in Petroleum Products and Other Bituminous Materials (Serial Designation: D 95);[1]

(*b*) *Softening Point:* Standard Method of Test for Softening Point of Tar Products (Cube-in-Water Method) (Serial Designation: D 61);[1]

(*c*) *Distillation:* Tentative Method of Test for Distillation of Bituminous Materials Suitable for Road Treatment (Serial Designation: D 20 - 27 T);[2]

(*d*) *Ductility:* Tentative Method of Test for Ductility of Bituminous Materials (Serial Designation: D 113 - 26 T);[3]

(*e*) *Total Bitumen:* Standard Method of Test for the Determination of Bitumen (Serial Designation: D 4).[1]

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[1] 1927 Book of A.S.T.M. Standards, Part II.

[2] See p. 954.

[3] *Proceedings*, Am. Soc. Testing Mats., Vol. 26, Part I, p. 886 (1926); also 1927 Book of A.S.T.M. Tentative Standards, p. 510.

TENTATIVE METHOD OF TEST
FOR
DISTILLATION OF BITUMINOUS MATERIALS SUITABLE FOR ROAD TREATMENT[1]

Serial Designation: D 20 - 27 T

This is a **Tentative Standard,** published for the purpose of eliciting criticism and suggestions, and as such is subject to annual revision.

ISSUED, 1926; REVISED, 1927.

This method is presented without any definition of its scope and accuracy since it is believed that it will become applicable to a wider range of materials than indicated by the title. So far the committee has determined its accuracy on one class of materials and further work will be done.

APPARATUS

Apparatus. 1. The apparatus consists of a flask, condenser tube, shield, receivers and thermometers as specified in Sections 2 to 6.

Flask. 2. *Flask.*—The distillation flask, Fig. 1, shall be a side neck distilling flask, having the following dimensions:

Diameter of bulb, outside	86	mm.	± 1.5 mm.
Diameter of neck, inside	22	mm.	± 1.0 mm.
Diameter of tubulature, inside	10.0	mm.	± 0.5 mm.
Length of neck	43	mm.	± 1.0 mm.
Distance, top of neck to tubulature	25	mm.	± 1.0 mm.
Length of tubulature	220	mm.	± 5.0 mm.
Angle of tubulature	73	deg.	± 1. deg.

Condenser Tube. 3. *Condenser Tube.*—The condenser tube shall be a suitable form of tapered glass tubing of the following dimensions:

Outside diameter of small end	12.5 mm.	permissible variation	± 1.5 mm.
Outside diameter of large end	28.5 mm.	permissible variation	± 3.0 mm.
Length	360.0 mm.	permissible variation	± 4.0 mm.
Length of tapered part	100.0 mm.	permissible variation	± 5.0 mm.

Shield. 4. *Shield.*—A galvanized iron shield, lined with $\frac{1}{8}$-in. asbestos, of the form and dimensions shown in Fig. 2 shall be used to protect the flask from air currents and to prevent radiation. The cover (top) may be of transit board, galvanized iron lined with $\frac{1}{8}$-in. asbestos, or of other suitable insulating material.

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[1] Criticisms of this Tentative Method are solicited, and should be directed to Mr. Prévost Hubbard, Secretary of Committee D-4 on Road and Paving Materials, 441 Lexington Ave., New York City.

This tentative method is in effect a revision of the Standard Method of Test for Distillation of Bituminous Materials Suitable for Road Treatment. The standard method, which was last published under the Serial Designation: D 20 - 18, has accordingly been withdrawn.

Receiver.

5. *Receiver.*—The distillates will be collected in tared Erlenmeyer flasks having a capacity of 50 to 100 ml.

Thermometer.

6. *Thermometer.*—The thermometer shall conform to the following requirements. These specifications cover a total-immersion thermometer graduated in either Centigrade or Fahrenheit degrees as specified, the range being from 0 to 400° C. or 30 to 760° F., respectively.

TYPE: Etched stem, glass.

LIQUID: Mercury.

RANGE AND SUBDIVISION: 0 to 400° C. in 1° C. or 30 to 760° F. in 2° F.

TOTAL LENGTH: 378 to 384 mm. (14.88 to 15.12 in.).

STEM: Plain front, enamel back, suitable thermometer tubing. Diameter, 6.0 to 7.0 mm. (0.24 to 0.28 in.).

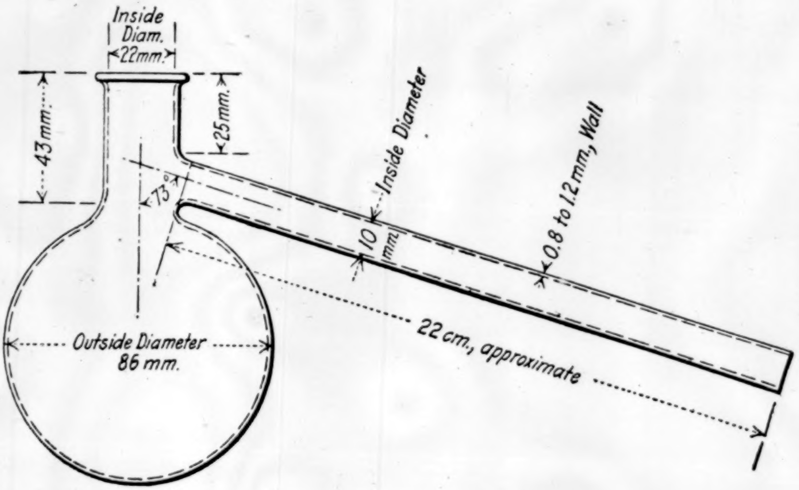

FIG. 1.—Distillation Flask.

BULB: Corning normal or equally suitable thermometric glass.
Length, 10 to 15 mm. (0.39 to 0.59 in.).
Diameter, 5.0 to 6.0 mm. (0.20 to 0.24 in.).

DISTANCE TO 0° C. OR 32° F. LINE FROM BOTTOM OF BULB: 25 to 35 mm. (0.98 to 1.38 in.).

DISTANCE TO 400° C. OR 752° F. LINE FROM TOP OF THERMOMETER: 30 to 45 mm. (1.18 to 1.77 in.).

FILLING ABOVE MERCURY: Nitrogen gas.

TOP FINISH: Glass ring.

GRADUATION: All lines, figures, and letters clear cut and distinct. The first and each succeeding 5° C. or 10° F. line to be longer than the remaining lines. Graduations to be numbered at each multiple of 10° C. or 20° F.

IMMERSION. Total.

SPECIAL MARKING: "A.S.T.M. High Distillation," a serial number and the manufacturer's name or trade mark shall be etched on the stem.

SCALE ERROR: The error at any point of the scale up to 370° C. or 700° F. when the thermometer is standardized as provided below shall not exceed 1° C. or 2° F.

STANDARDIZATION: The thermometer shall be standardized immersed in the testing bath to the top of the mercury column, at the ice point and at temperature intervals of approximately 50° C. or 100° F. up to 370° C. or 700 °F.

TEST FOR PERMANENCY OF RANGE: After being subjected to a temperature between 360 and 370° C. or 680 and 700° F. for 24 hours, the accuracy shall be within the limit specified.

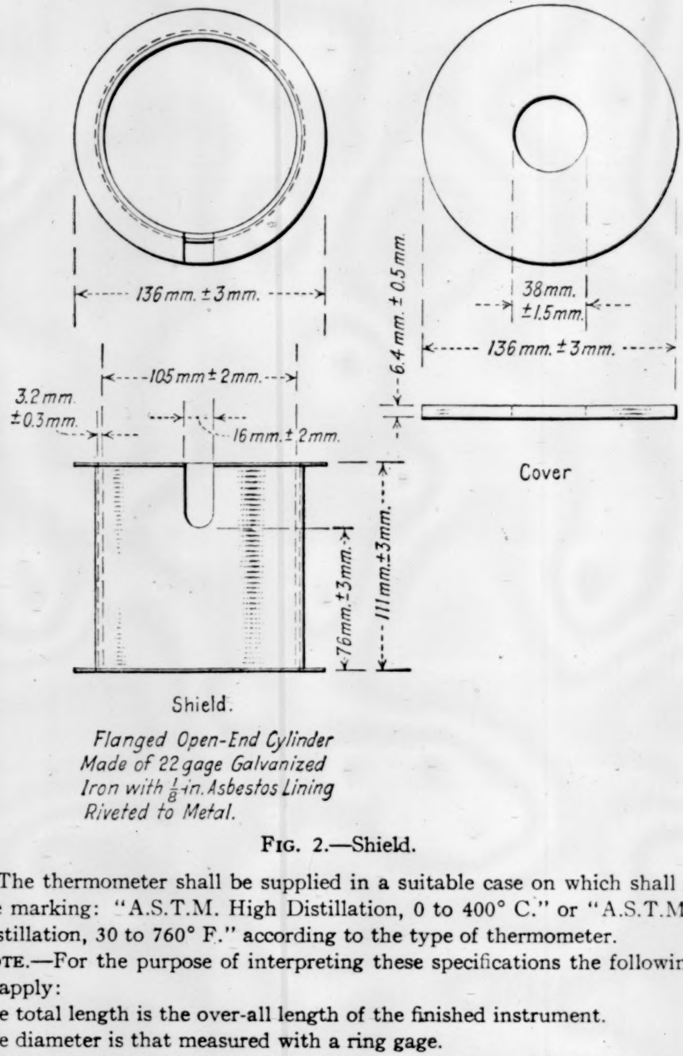
136 mm. ± 3 mm.
6.4 mm. ± 0.5 mm.
38 mm. ± 1.5 mm.
136 mm. ± 3 mm.
105 mm ± 2 mm.
3.2 mm. ± 0.3 mm.
16 mm. ± 2 mm.
111 mm. ± 3 mm.
76 mm. ± 3 mm.
Cover
Shield.
Flanged Open-End Cylinder Made of 22 gage Galvanized Iron with 1/8-in. Asbestos Lining Riveted to Metal.

FIG. 2.—Shield.

CASE: The thermometer shall be supplied in a suitable case on which shall appear the marking: "A.S.T.M. High Distillation, 0 to 400° C." or "A.S.T.M. High Distillation, 30 to 760° F." according to the type of thermometer.

NOTE.—For the purpose of interpreting these specifications the following definitions apply:

The total length is the over-all length of the finished instrument.

The diameter is that measured with a ring gage.

The length of the bulb is the distance from the bottom of the bulb to the beginning of the enamel backing.

The top of the thermometer is the top of the finished instrument.

PREPARATION OF SAMPLE

Sampling. 7. The sample, as received, shall be thoroughly stirred and agitated, warming, if necessary, to insure a complete mixture before the portion for analysis is removed.

Dehydration. 8. The material may be tested for distillation without dehydration, if water is present not to exceed 2.0 per cent. If water is present in excess of 2.0 per cent, the bituminous material shall be dehydrated before distillation in accordance with the method for dehydration as given in Sections 2 to 4 of the Standard Methods of Sampling and Analysis of Creosote Oil (Serial Designation: D 38) of the American Society for Testing Materials.[1]

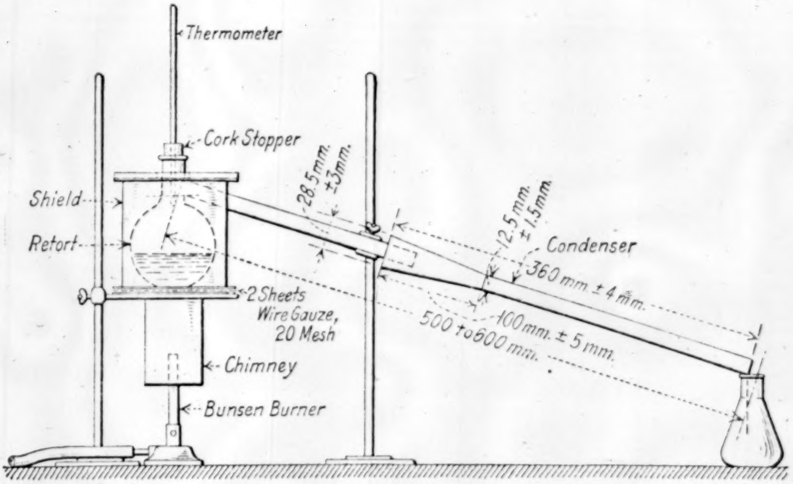

FIG. 3.—Distillation Apparatus Assembly.

PROCEDURE

Assembling Apparatus for Distillation Test. 9. (*a*) The flask shall be supported on a tripod or rings over two sheets of 20-mesh gauze, 150 mm. square, as shown in Fig. 3. It shall be connected to the condenser tube by a tight cork joint. The thermometer shall be inserted through a cork in the neck with the top of the bulb level with the lowest point of juncture of the tubulature and neck of the flask.

(*b*) The axis of the flask through the neck shall be vertical.

(*c*) The distance from the bulb of the thermometer to the outlet end of the condenser tube shall be not more than 600 nor less than 500 mm. The burner should be protected from draughts by a suitable shield or chimney (see Fig. 3).

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[1] 1927 Book of A.S.T.M. Standards, Part II.

Distillation Test.

10. (*a*) One hundred grams (100 g. ± 0.1 g.) of the sample shall be weighed into the flask, the apparatus assembled and heat applied so that the first drop comes over in from 5 to 15 minutes. The distillation shall be conducted at the rate of between 50 and 70 drops per minute and the distillate collected in weighed receivers. The condenser tube shall be warmed whenever necessary to prevent accumulation of solid distillates. The fraction shall be collected at the points designated by the specifications. The receivers shall be changed when the thermometer indicates the maximum temperature for each fraction. When the maximum specified temperature of the test is indicated by the thermometer, the flame shall be removed and any oil which has condensed in the condenser tube shall be drained into the last fraction.

(*b*) The residue shall remain in the flask with the cork and thermometer in position until no vapors are visible and it shall then be weighed. If tests of the residue are required, the flask shall then be inclined so that the residue will flow around the sides, thus collecting any condensed vapors that may be on the sides of the flask, after which the residue shall be poured into a suitable receptacle and covered. If the residue becomes so cool that it cannot be poured readily from the flask, it shall be reheated to a temperature not exceeding 125° C. by holding the bulb of the flask in a suitable bath and not by the application of flame.

For weighing the receivers and fractions, a balance accurate to at least 0.05 g. shall be used.

(*c*) During the progress of the distillation the thermometer shall remain in its original position. No correction shall be made for the emergent stem of the thermometer.

(*d*) The results of the distillation test shall be reported in percentages by weight of water-free material. The following fractions are usually reported:

Up to 170° C.
170 to 235° C.
235 to 270° C.
270 to 300° C.
Residue.

TENTATIVE METHODS
FOR THE
DETERMINATION OF SULFUR IN COAL AND COKE BY THE BOMB-WASHING AND SODIUM PEROXIDE FUSION METHODS[1]

Serial Designation: D 271 - 27 T

This is a **Tentative Standard,** published for the purpose of eliciting criticism and suggestions, and as such is subject to annual revision.

ISSUED, 1927.

BOMB-WASHING METHOD

METHOD

Ignition.—Sulfur is determined in the washings from the oxygen-bomb calorimeter following the calorimetric determination. The type of bomb, amount of water in the bomb, oxygen pressure, and amount of sample taken shall be the same as specified under the calorimetric determination. The bomb shall stand in the calorimeter water for not less than 5 minutes after firing.

Subsequent Treatment.—Remove the bomb from the calorimeter water and open the valve carefully so as to allow the gases to escape at an approximately even rate so the pressure is reduced to atmospheric in not less than 1 minute. Bombs equipped with valves other than needle valves, such as compression valves, shall be provided with a device so the valve can be controlled to permit a slow and uniform release of the gases. Open the bomb and examine the inside for traces of unburned material or sooty deposit. If these are found, the determination shall be discarded. Wash carefully all parts of the interior of the bomb, including the tray, with a fine jet of distilled water containing 1 cc. per liter of a saturated solution of methyl orange, until no acid reaction is observed. It is essential to wash through the valve opening in the case of bombs equipped with compression valves, or other types of valves with large openings, as considerable spray may collect in such valve openings.

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[1] Criticisms of these Tentative Methods are solicited and should be directed to Mr. W. A. Selvig, Secretary of Committee D-5 on Coal and Coke, U. S. Bureau of Mines, 4800 Forbes St., Pittsburgh, Pa.

These tentative methods, when adopted as standard, will be added to the present Standard Methods of Laboratory Sampling and Analysis of Coal and Coke (Serial Designation: D 271), 1927 Book of A.S.T.M. Standards, Part II.

Collect the washings in a 250-cc. beaker and titrate with standard alkali solution to obtain the "acid correction" for the heating value, as specified under the calorimetric determination. Add 1 cc. of NH_4OH (sp. gr. 0.90), heat the solution to boiling, and filter through qualitative filter paper. Wash the residue and filter paper thoroughly five or six times with hot distilled water. To the filtrate and washings, amounting to about 250 cc., add 1 cc. of saturated bromine water and sufficient HCl to make it slightly acid. Boil the solution to expel the excess bromine. Adjust the acidity and precipitate and determine the sulfur, as specified under the Eschka method.[1]

SODIUM PEROXIDE FUSION METHOD

APPARATUS

Combustion Bomb.—The Parr coal sulfur bomb, or its equivalent, shall be used. The bomb shall have an inner surface which is not attacked by the chemicals on ignition of the charge.

Reagents.—Sulfur-free powdered sodium peroxide (Na_2O_2), powdered c. p. potassium perchlorate ($KClO_4$) or potassium chlorate ($KClO_3$), and powdered c. p. benzoic acid shall be used.

METHOD

Place 1 g. of $KClO_4$ or $KClO_3$ in a dry sulfur bomb and break up any lumps that occur. Add a 0.5-g. sample and mix thoroughly with a glass rod. Then add one measure (about 15 g.) sodium peroxide, close the bomb and mix thoroughly by shaking. In the case of cokes or anthracites, or coals excessively high in ash which fail to ignite or fuse properly (as indicated by the fusion being honeycombed in appearance), add 0.3 g. of benzoic acid to the bomb at the time the chlorate and sample are added. It should be noted that a mixture of potassium chlorate and organic matter alone produces a mixture of extremely explosive properties. One of the important functions of the sodium peroxide is to provide a diluent, thus slowing down the reaction, so care should be taken that it is not omitted in the charge. Potassium perchlorate is fully equal if not superior to the $KClO_3$, and is without turbulence in its reaction.

Fasten the cover securely to the bomb and ignite the charge by applying a sharply pointed flame from a blast lamp to the bottom of the bomb for a brief period, or by electric ignition, according to the type of bomb used. Allow 1 minute for complete combustion to take place after ignition, then cool under the tap or in a vessel of water.

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[1] Standard Methods of Laboratory Sampling and Analysis of Coal and Coke (Serial Designation: D 271) of the American Society for Testing Materials, 1927 Book of A.S.T.M. Standards, Part II.

Remove the cover from the bomb, place the bomb on its side in a 400-cc. beaker and wash off the cover with a fine jet of hot distilled water. Place a watch glass over the beaker and cautiously add about 100 cc. of hot distilled water. After the contents of the bomb have dissolved, remove and rinse it carefully with the distilled water. Add slowly, concentrated HCl to the neutral point, then add 1 to 2 cc. of the acid in excess. Filter through qualitative filter paper into a 600-cc. beaker and wash thoroughly five or six times with distilled water. Dilute the filtrate to approximately 400 cc. and precipitate the sulfur with barium chloride and determine as specified under the Eschka method.[1]

Blank Correction.—A blank correction shall be applied by running a blank on the reagents used.

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[1] Standard Methods of Laboratory Sampling and Analysis of Coal and Coke (Serial Designation: D 271) of the American Society for Testing Materials, 1927 Book of A.S.T.M. Standards, Part II.

TENTATIVE DEFINITIONS
OF
TERMS RELATING TO COAL AND COKE[1]

Serial Designation: D 121 - 27 T

This is a Tentative Standard, published for the purpose of eliciting criticism and suggestions, and as such is subject to annual revision.

ISSUED, 1921; REVISED, 1924, 1926, 1927.

Coke.—The infusible, cellular, coherent solid material obtained from coal as the residue from its destructive distillation.

NOTE 1.—Such material obtained from the destructive distillation of petroleum or petroleum residues is known as "petroleum coke."

NOTE 2.—Such material obtained from the destructive distillation of coal-tar pitch is known as "pitch coke."

Beehive Coke.—Coke manufactured in beehive, rectangular, or similar forms of ovens in a horizontal bed, where heat for the coking process is secured by combustion within the oven chamber.

By-Product Coke.—Coke manufactured with attendant recovery of by-products, in ovens that are heated externally, and having properties making it available for metallurgical purposes.

Coke Breeze.—The fine screenings from crushed coke or from coke as taken from the ovens, of a size varied in local practice but usually passing a $\frac{1}{2}$-in. or $\frac{3}{4}$-in. screen opening.

Dry Coke.—Coke which has been dried to constant weight at temperatures not less than 104° C. nor more than 200° C. in the case of lump coke, and between 104 and 110° C. in the case of coke passing a No. 60 sieve, in accordance with methods of determining moisture prescribed in the Standard Methods of Laboratory Sampling and Analysis of Coal and Coke (Serial Designation: D 271) of the American Society for Testing Materials.[2]

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[1] Criticisms of these Tentative Definitions are solicited and should be directed to Mr. W. A. Selvig, Secretary of Committee D-5 on Coal and Coke, U. S. Bureau of Mines, 4800 Forbes St., Pittsburgh, Pa.

[2] 1927 Book of A.S.T.M. Standards, Part II.

TENTATIVE METHOD OF TEST
FOR
DISTILLATION OF CREOSOTE OIL[1]

Serial Designation: D 246 - 27 T

This is a **Tentative Standard,** published for the purpose of eliciting criticism and suggestions, and as such is subject to annual revision.

ISSUED, 1926; REVISED, 1927.

Scope. 1. This method of test is suitable for all types and grades of creosote and mixtures of creosote with tars and oils used for timber preservation.

APPARATUS

Flask. 2. *Flask.*—The distillation flask, Fig. 1, shall be a side neck distilling flask, having the following dimensions:

Diameter of bulb (outside)	86 mm.	± 1.5 mm.
Diameter of neck (inside)	22 "	± 1.0 "
Diameter of tubulature (inside)	10 "	± 0.5 "
Length of neck	43 "	± 1 "
Distance, top of neck to tubulature	25 "	± 1 "
Angle of tubulature	73 deg.	± 1 deg.
Length of tubulature	22 cm.	± 0.5 cm.

Condenser Tubes. 3. *Condenser Tube.*—The condenser tube shall be a suitable form of tapered glass tubing of the following dimensions:

Diameter of small end	12.5 mm.	permissible variation	± 1.5 mm.
Diameter of large end	28.5 "	permissible variation	± 3.0 "
Length	360.0 "	permissible variation	± 4.0 "
Length of tapered part	100.0 "	permissible variation	± 5.0 "

Shield. 4. *Shield.*—A galvanized iron shield, lined with $\frac{1}{8}$-in. asbestos, of the form and dimensions shown in Fig. 2 shall be used to protect the flask from air currents and to prevent radiation. The cover (top) may be of transit board, galvanized iron lined with $\frac{1}{8}$-in. asbestos, or of other suitable insulating material.

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[1] Criticisms of this Tentative Method are solicited, and should be directed to Mr. J. A. Newlin, Secretary of Committee D-7 on Timber, U. S. Forest Products Laboratory, Madison, Wis.

Receivers. 5. *Receivers.*—The distillates shall be collected in tared Erlenmeyer flasks having a capacity of 100 ml.

Thermometer. 6. *Thermometer.*—The thermometer shall conform to the following requirements. These specifications cover a total immersion thermometer graduated in either Centigrade or Fahrenheit degrees as specified, the range being from 0 to 400° C. or 30 to 760° F., respectively.

TYPE: Etched stem, glass.

LIQUID: Mercury.

RANGE AND SUBDIVISION: 0 to 400° C. in 1° C. or 30 to 760° F. in 2° F.

TOTAL LENGTH: 378 to 384 mm. (14.88 to 15.12 in.).

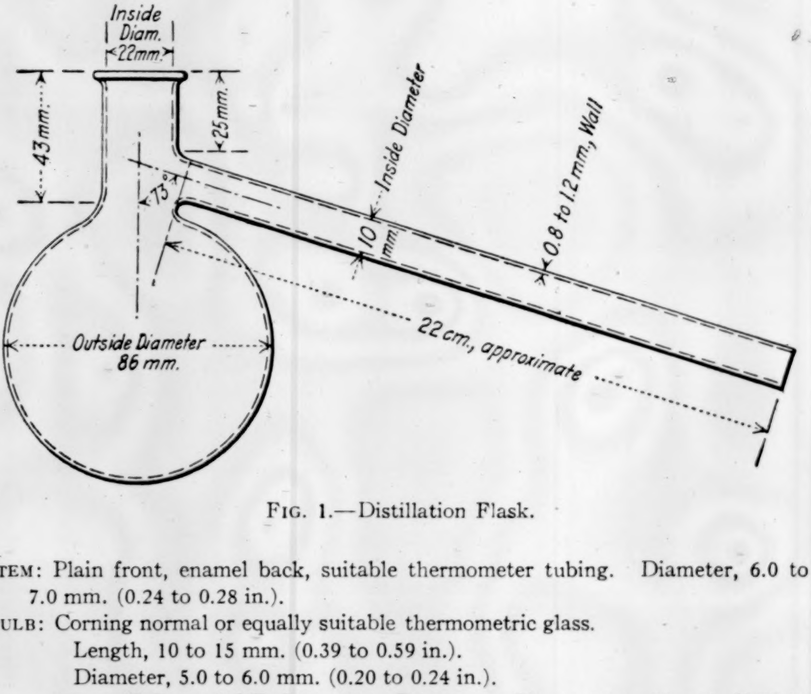

FIG. 1.—Distillation Flask.

STEM: Plain front, enamel back, suitable thermometer tubing. Diameter, 6.0 to 7.0 mm. (0.24 to 0.28 in.).

BULB: Corning normal or equally suitable thermometric glass.
    Length, 10 to 15 mm. (0.39 to 0.59 in.).
    Diameter, 5.0 to 6.0 mm. (0.20 to 0.24 in.).

DISTANCE TO 0° C. OR 32° F. LINE FROM BOTTOM OF BULB: 25 to 35 mm. (0.98 to 1.38 in.).

DISTANCE TO 400° C. OR 752° F. LINE FROM TOP OF THERMOMETER: 30 to 45 mm. (1.18 to 1.77 in.).

FILLING ABOVE MERCURY: Nitrogen gas.

TOP FINISH: Glass ring.

GRADUATION: All lines, figures, and letters clear cut and distinct. The first and each succeeding 5° C. or 10° F. line to be longer than the remaining lines. Graduations to be numbered at each multiple of 10° C. or 20° F.

IMMERSION: Total.

SPECIAL MARKING: "A.S.T.M. High Distillation," a serial number and the manufacturer's name or trade mark shall be etched on the stem.

SCALE ERROR: The error at any point of the scale up to 370° C. or 700° F. when the thermometer is standardized as provided below shall not exceed 1° C. or 2° F.

STANDARDIZATION: The thermometer shall be standardized immersed in the testing bath to the top of the mercury column, at the ice point and at temperature intervals of approximately 50° C. or 100° F. up to 370° C. or 700° F.

TEST FOR PERMANENCY OF RANGE: After being subjected to a temperature between 360 and 370° C. or 680 and 700° F. for 24 hours, the accuracy shall be within the limit specified.

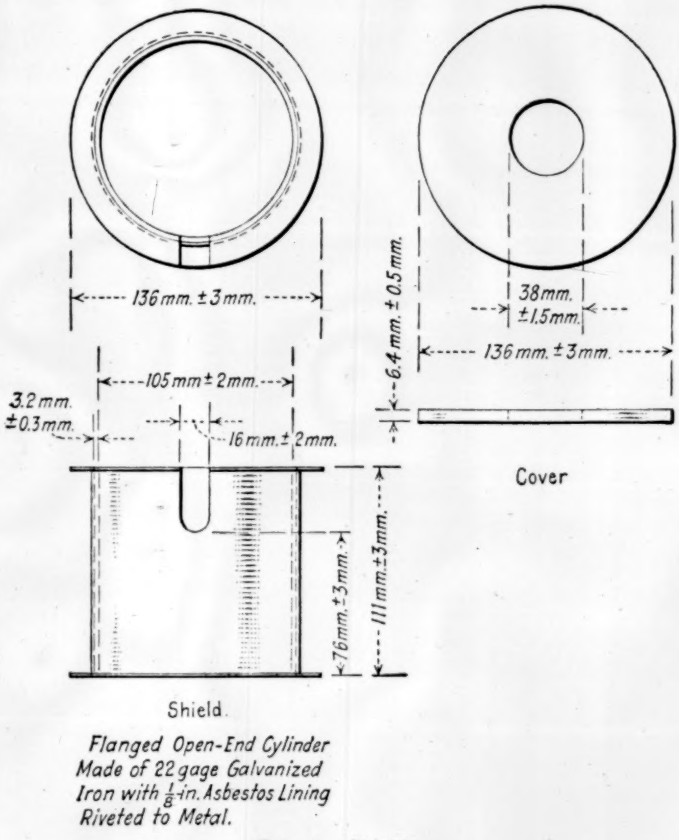
136 mm. ± 3 mm.
105 mm ± 2 mm.
3.2 mm. ±0.3 mm.
16 mm. ± 2 mm.
76 mm. ± 3 mm.
111 mm. ± 3 mm.
6.4 mm. ± 0.5 mm.
38 mm. ±1.5 mm.
136 mm. ± 3 mm.
Cover
Shield.
Flanged Open-End Cylinder Made of 22 gage Galvanized Iron with $\frac{1}{8}$-in. Asbestos Lining Riveted to Metal.

FIG. 2.—Shield.

CASE: The thermometer shall be supplied in a suitable case on which shall appear the marking: "A.S.T.M. High Distillation, 0 to 400° C." or "A.S.T.M. High Distillation, 30 to 760° F." according to the type of thermometer.

NOTE.—For the purpose of interpreting these specifications the following definitions apply:

The total length is the over-all length of the finished instrument.

The diameter is that measured with a ring gage.

The length of the bulb is the distance from the bottom of the bulb to the beginning of the enamel backing.

The top of the thermometer is the top of the finished instrument.

PREPARATION OF SAMPLE

Sample. 7. The sample as received should be thoroughly stirred and agitated, warming if necessary to insure a complete mixture free from crystallized solids, before the portion for analysis is removed.

Dehydration. 8. If the presence of water is suspected or known, the oil shall be dehydrated before distillation in accordance with the method for dehydration as given in Sections 2 to 4 of the Standard Methods of Sampling and Analysis of Creosote Oil (Serial Designation: D 38) of the American Society for Testing Materials.[1]

PROCEDURE

Assembling Apparatus. 9. The flask shall be supported on a tripod or rings over two sheets of 20-mesh gauze, 150 mm. square, as shown in Fig. 3. It shall be connected to the condenser tube by a tight cork joint. The thermometer shall be inserted through a cork in the tubulature with the bottom of the bulb 12 to 13 mm. from the surface of the oil in the retort. The exact location of the thermometer bulb shall be determined by placing a vertical rule graduated in divisions not exceeding 1 mm. back of the retort, when the latter is in position for the test, and sighting the level of the liquid and the point for the bottom of the thermometer bulb.

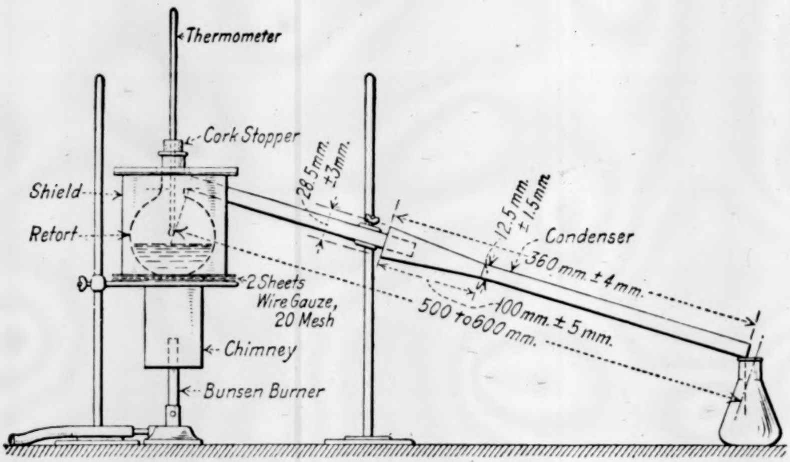

FIG. 3.—Distillation Apparatus Assembly.

The axis of the bulb through the tubulature shall be vertical.

The distance from the bulb of the thermometer to the outlet end of the condenser tube shall be not more than 600 nor less than 500 mm.

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[1] 1927 Book of A.S.T.M. Standards, Part II.

The burner should be protected from draughts by a suitable shield or chimney, see Fig. 3.

Distillation Test.

10. (*a*) One hundred grams (100 g. ± 0.1 g.) of the sample shall be weighed into the flask, the apparatus assembled and heat applied so that the first drop comes over in from 5 to 15 minutes. The distillation shall be conducted at the rate of between 80 and 120 drops per minute and the distillate collected in weighed receivers. The condenser tube shall be warmed whenever necessary to prevent accumulation of solid distillates. Fractions shall be collected at the points designated by the specifications. The receivers shall be changed as the mercury passes the dividing temperature for each fraction. When the maximum specified temperature of the test is indicated by the thermometer, the flame shall be removed and any oil which has condensed in the condenser tube shall be drained into the last fraction.

(*b*) The residue shall remain in the flask with the cork and the thermometer in position until no vapors are visible; it shall then be weighed. The flask shall then be tipped around so that the residue will flow around the sides, thus collecting any condensed vapors that have collected on the sides of the flask, after which the residue shall be poured into the brass collar used in the float test or into a suitable receptacle and covered. If the residue becomes so cool that it cannot be poured readily from the flask, it shall be reheated to a temperature not exceeding 125° C. by holding the bulb of the flask in a suitable bath and not by the application of flame.

(*c*) For weighing the receivers and fractions, a balance accurate to at least 0.05 g. shall be used.

(*d*) During the progress of the distillation the thermometer shall remain in its original position. No correction shall be made for the emergent stem of the thermometer.

(*e*) The following fractions should be reported:[1]

0 - 210° C.
210 - 235° C.
235 - 270° C.
270 - 315° C.
315 - 355° C.
Residue.

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[1] The fraction 235-270° C. is not usually required in creosote specifications, but it is recommended that this cut be made, since it gives useful information and does not materially increase the operator's labor.

TENTATIVE METHODS OF ANALYSIS OF ROOFING FELT FOR FIBER COMPOSITION[1]

Serial Designation: D 272 – 27 T

This is a **Tentative Standard,** published for the purpose of eliciting criticism and suggestions, and as such is subject to annual revision.

ISSUED, 1927.

Scope. 1. These methods cover the examination of roofing felt to determine the percentage of various fibers contained therein.

SAMPLING

Sampling. 2. (*a*) From a shipment of rolls of felt to be tested representing a product of the same kind, class, and weight, a number of rolls shall be selected at random, equivalent to one-half the cube root of the total number of rolls in the lot, except that in lots of 1000 or less, 5 rolls shall be taken. From each roll a sample 1 in. in width across the width of the roll shall be taken from the first unharmed layer of the roll. The strips shall then be reduced in the laboratory to a sample of about 25 g. by cutting at least 100 small sections from different portions of the various strips taken for test.

(*b*) If the sample to be examined is an extracted felt obtained from the examination of a saturated felt or prepared roofing, the sample of 25 g. shall be obtained by cutting at least 100 small sections from different portions of the extracted felt obtained from the saturated felt or prepared roofing.

APPARATUS

Apparatus. 3. (*a*) *Microscope.*—The microscope shall be capable of giving a magnification of not less than 100 diameters and shall be of the compound type, provided with a mechanical stage, and substage condenser.

(*b*) *Graticule.*—The graticule or cross-line disk, for insertion into the eye-piece of the microscope, shall be ruled with two fine lines intersecting approximately at right angles.

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[1] Criticisms of these Tentative Methods are solicited and should be directed to Mr. Prévost Hubbard, Secretary of Committee D-8 on Bituminous Waterproofing and Roofing Materials, 441 Lexington Ave., New York City.

(*c*) *Dropper.*—The dropper shall consist of a glass tube 20 cm. in length and 6 mm. in internal diameter fitted at one end with a rubber bulb and having the other end carefully smoothed but not constricted in a flame.

4. *Herzberg Stain.*—The Herzberg stain used shall be prepared as follows: **Stain.**

Solution A.—Dissolve 50 g. of dry zinc chloride (fused sticks) in 25 cc. of distilled water, added to the zinc chloride bottle with a pipette. Stopper the bottle and shake well. There should be approximately 40 cc. of the solution.

The specific gravity of the solution determined at 28° C. shall be 1.8. If the specific gravity is not 1.8, add distilled water until the specific gravity is 1.8, and then pour the solution into a tall cylinder.

Solution B.—Wash the thermometer, hydrometer, and the original bottle containing the zinc chloride with a portion of 12.5 cc. of distilled water. Add this to Solution *A* in the tall cylinder.

Dissolve 5.25 g. of potassium iodide and 0.25 g. of iodine in the balance of the 12.5 cc. of distilled water, and add to Solution *A* in the tall cylinder.

Stir the solution in the tall cylinder well, and place in the dark. The following day, pipette off the clear portion into a black bottle, leaving 3 or 4 cc. of the solution above the sediment. Add a leaf of crystal iodine.

This stain should ordinarily be found to be satisfactory for at least two weeks. If for any reason the stain is unsatisfactory, it shall not be adjusted but new stain shall be prepared. On referee tests, no stain over seven days old shall be used.

PREPARATION OF SAMPLE

5. Ten grams of the sample shall be treated in a 400-cc. beaker with 200 cc. of NaOH solution (0.5-per-cent) and heated to boiling. Stir the liquid thoroughly, preferably with a mechanical stirrer, until the sample is well pulped and the fibers well separated. The mass shall then be placed on a No. 100 (149 micron) sieve and washed thoroughly with water. The moist mass of paper retained on the sieve shall then be rolled into a ball and worked between the fingers to loosen the fibers thoroughly. Approximately one-fourth of this sample shall then be placed in a stoppered bottle and shaken thoroughly with 250 cc. of water until the fiber mass is thoroughly disintegrated and separated. Transfer about 25 cc. of this suspension to another bottle and dilute with water to 250 cc., so as to obtain a suspension of about 0.1 per cent pulp. This suspension shall be thor- **Preparation of Sample.**

oughly shaken before withdrawing a sample for the microscope test described in Section 6.

PROCEDURE

Preparation of Slide.

6. The fibers shall be transferred from the 0.1-per-cent pulp suspension to the microscopic slide as follows: Thoroughly mix the fibers and water by shaking thoroughly, quickly insert the dropper into the mixture 5 cm. (2 in.) below the surface, expel two bubbles of air from the dropper, then fill the tube to a distance of about 13 mm. ($\frac{1}{2}$ in.). Transfer the contents of the dropper to the slide, making four drops, completely emptying it. Repeat this procedure until the slide is uniformly covered with drops of the suspension, then place the slide in an air-bath until dry. Add stain to the slide by means of an ordinary dropper so as to uniformly cover the fibers with the stain. Allow to stand for 2 minutes, remove most of the excess stain with hard, clean-cut filter paper and press down a second slide or suitable cover glasses on the fibers. Remove the remaining excess of stain with absorbent paper.

Method of Observation.

7. Place the round-glass graticule on the diaphragm of the microscope. The point formed by the intersection of the two fine lines ruled on the graticule shall be used as the eye-piece reference point. Starting at one side of the slide about one-fourth of the way from the top, the slide shall be moved in a straight line across its entire width, by means of the mechanical stage. In moving thus through the field of view, each fiber or part of a fiber shall be counted which touches the eye-piece reference-point. Some of the fibers may be long and come under the point twice or more, but they shall be counted each time. If aggregations of fibers, such as occur in ground wood, are encountered, the number of single fibers in the aggregation shall be estimated and figured as if the individual fibers were completely separated. Another path across the slide shall be selected, about half way down from the top. The entire counting process shall be repeated and the results added to those obtained above. Repeat again over a path about three-fourths of the way down from the top and add the results to the total as before. Select two or more up-and-down paths and repeat the process. In this manner not less than 200 fibers shall be counted on each slide, depending upon the thickness of fibers on the slide. An examination of three such slides, involving the counting of not less than 600 fibers, shall constitute a test.

The fibers may be recognized (Note 3) by the colors developed by the stain, and by the surface appearance and markings on the fibers themselves.

COLOR	FIBER COMPOSITION
Red	Linen, cotton, bleached Manila hemp.
Blue	Chemically prepared fibers from wood, straw, and esparto.
Yellow (various shades to brown)	Ground wood, sawdust, jute, and Manila (Note 1).
Colorless	Wool (Note 2).

NOTES

NOTE 1.—Ground wood and sawdust (mechanical wood) may be distinguished from jute and manila by the broken ends of the fibers, round, circular pits on the surface of the fibers as well as ray-like structure of portions of certain of the woods.

NOTE 2.—Wool fibers are also often variously colored from the dye to which the wool has been subjected prior to its use as a raw material for roofing felts and in such cases must be recognized by its regular cylindrical appearance, scale, and hook-like markings.

NOTE 3.—Proficiency and experience in recognizing the appearance and structure of the various fibers are essential for accurate testing. It is recommended that all operators carrying on the tests obtain *Technologic Paper No. 250*, of the Bureau of Standards, entitled "Pulp and Paper Fiber Composition Standards," which contains color plates of various fibers treated with the Herzberg stain. A study of these plates, together with preparation of slides from known materials, is necessary to familiarize the operator with the characteristics of the various fibers and thereby perfect his technique.

RESULTS

Calculation of Results.

8. The proportion of fibers found shall be reported in terms of percentage by counts of the total fiber composition and the following classes reported:

1. Cotton, linen, and bleached Manila hemp ....
2. Chemical wood, straw, and esparto ....
3. Mechanical wood ....
4. Jute, and Manila ....
5. Wool ....
6. Unidentified fibers ....

TENTATIVE METHOD OF TEST
FOR
WATER ABSORPTION OF SLATE[1]

Serial Designation: D 221 - 27 T

This is a **Tentative Standard,** published for the purpose of eliciting criticism and suggestions, and as such is subject to annual revision.

ISSUED, 1925; REVISED, 1927.

It is often desirable to gain some idea of the porosity of a material in question. Actual determinations of the pore space require the use of rather elaborate and refined equipment as well as considerable precision in carrying out the tests. For comparative purposes the absorption test affords a simple and sufficiently accurate means of obtaining the desired information. As applied to slate this test requires somewhat more care and precision than many other materials because of its dense nature and, consequently, the small quantities to be dealt with. Furthermore, the cleavage of slate—that property which permits it to be split into thin sheets of uniform thickness—must be taken into consideration when this test is made. On this account misleading results are often obtained on cubical specimens due to accidental cleavage cracks in the specimens. The shapes of specimens and larger number of specimens recommended in the following procedure are intended to eliminate to a large extent, the inconsistent results which may be obtained on this material.

TEST SPECIMENS

Size of Specimens.

1. The specimens shall be 6 by 6 in. measured in the direction of cleavage and $\frac{1}{4}$ in. in thickness.

Preparation of Specimens.

2. Preferably the specimens should be split to a thickness somewhat greater than $\frac{1}{4}$ in., sawed into 6-in. squares and finished on the faces and edges with a hone or fine abrasive to plane surfaces. Where this is not practical the slate may be split as nearly as possible to the desired thickness, sawed into 6-in. squares, and tested in this form.[2]

Number of Specimens.

3. The number of specimens shall depend on the manner of preparation as follows:

Hone finished on faces and edges	6
Cleavage faces and sawed edge	9

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[1] Criticisms of this Tentative Method are solicited and should be directed to Mr. D. K. Boyd, Secretary of Committee D-16 on Slate, Structural Service Bureau, Otis Building, Philadelphia, Pa.

[2] In testing slate shingles which have sheared edges, this type of specimen can be readily cut from the shingle with a hacksaw of the type in which the blade can be set at right angles to the frame.

PROCEDURE

Drying. 4. The specimens shall be dried in an oven at a temperature between 110 and 120° C. for a period of 24 hours.

Initial Weighing. 5. After drying, the specimens may be cooled in the room for 15 minutes and then weighed. In cases where it is not possible to weigh the specimens immediately upon cooling, they shall be placed in a desiccator. The weights shall be determined to the nearest 0.05 g.

Immersion. 6. After the initial weighing the specimens shall be wholly immersed in water at approximately 20° C. for 48 hours. At the end of this period all faces and edges shall be thoroughly wiped off with a dry cloth, and the specimens immediately weighed to the same precision as employed for the initial weights.

Computation of Results. 7. The percentage of absorption shall be calculated from the formula:

$$\text{Percentage of absorption} = \frac{(B-A)100}{A}$$

where A = dry weight of specimen and B = weight of specimen after immersion.

Reporting Results. 8. In general the average of all the tests shall be reported as the absorption of the slate. Individual determinations which differ by more than 25 per cent from the average of all the determinations may be disregarded when there is evidence that such results are of uncertain value. The absorption shall then be reported as the average of the remaining determinations, but all determinations shall be reported as information.

ALTERNATIVE METHOD

Occasionally it is desirable to obtain results in a shorter period than that required by the above procedure. In such cases, the 48-hour immersion period may be supplanted by an 8-hour boiling period. In this procedure the different steps are the same as the foregoing method up to that of immersion. Instead of allowing the specimens to soak for 48 hours they may be placed in an enameled pan or other suitable vessel, covered with water and boiled for 8 hours. Before the final weighing the specimens shall be cooled by allowing tap water to flow over them for at least 30 minutes. The computation and reporting of results are as outlined in the above procedure. Eight hours boiling has been found to give practically the same saturation as 48 hours soaking.

TENTATIVE METHODS OF FLEXURE TESTING OF SLATE[1]

(DETERMINATION OF MODULUS OF RUPTURE AND MODULUS OF ELASTICITY)

Serial Designation: D 222 - 27 T

This is a **Tentative Standard,** published for the purpose of eliciting criticism and suggestions, and as such is subject to annual revision.

Issued, 1925; Revised, 1927.

Due to the unique properties of slate the flexure test is better adapted to use for strength and elasticity determinations than either compression or tension tests. Furthermore, several uses of slate are such that these determinations are of special interest and value, besides furnishing comparative data.

The property of slate termed "grain" causes a slab of the material to break transversely in one direction somewhat more readily than at right angles to this direction. For this reason it is desirable to test the strength and elasticity both parallel and perpendicular to the grain.

In the quarrying of slate, blasting is frequently resorted to and for this reason certain portions of the material may have been unduly strained. Low or erratic strength results on some of the test specimens should be regarded in the light of defective material.

It is sometimes desirable to determine the modulus of rupture and modulus of elasticity of slate in one operation. The shape of specimens recommended for modulus of rupture under Method *A* is not well adapted to elasticity measurements. However, a shape may be chosen which is adapted to both tests. That recommended under Method *B* will be found more convenient for use on roofing slates.

A. Modulus of Rupture

TEST SPECIMENS

Number and Size of Specimens. 1. Six representative specimens, 12 by $1\frac{1}{2}$ by 1 in. in size, of the particular slate under consideration shall be submitted for this test.

Preparation of Specimens. 2. The slate for test shall have been split to a thickness of approximately $1\frac{1}{4}$ in. and then sawed into strips 12 in. in length by $1\frac{1}{2}$ in. in width. Half of these shall be cut with the length parallel to the grain and the other half with the length perpendicular to the grain. The 12 by $1\frac{1}{2}$ in. faces shall then be planed to smooth surfaces and rubbed down to a thickness of approximately 1 in., care being taken to have the finished faces as nearly parallel as practical.

Note.—The shapes of specimens recommended for modulus of rupture and elasticity tests were determined partly by consideration of the proportions best adapted to the respective tests and partly on account of the convenience of preparing them from stock material. The small sizes recommended were first for economy of material and second, to permit the use of lighter testing equipment. Where only the large machines are available it is desirable, in order to obtain consistent results, to use larger specimens. In such cases approximately the same proportionate dimensions should be adhered to for the respective tests.

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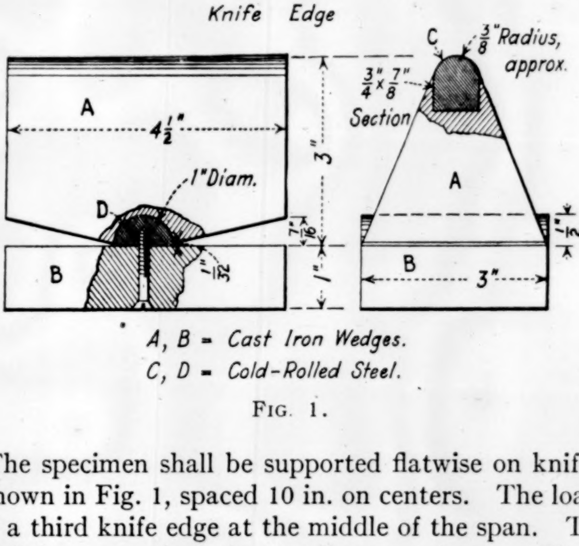
[1] Criticisms of these Tentative Methods are solicited and should be directed to Mr. D. K. Boyd, Secretary of Committee D-16 on Slate, Structural Service Bureau, Otis Building, Philadelphia, Pa.

PROCEDURE

Drying. 3. Before testing, the specimens shall be dried in an oven at a temperature of 110 to 120° C. for 24 hours.

Measuring Specimens. 4. The thickness and the width of the specimen at the middle shall be measured to the nearest 0.01 in.

Testing. 5. The testing machine shall be sensitive to 5 lb. when loaded to 500 lb. The specimen shall be supported flatwise on knife edges of the type shown in Fig. 1, spaced 10 in. on centers. The load shall be applied by a third knife edge at the middle of the span. The rate of loading shall be approximately 100 lb. per minute. The breaking load shall be recorded to the nearest 5 lb.



A, B = Cast Iron Wedges.
C, D = Cold-Rolled Steel.

FIG. 1.

Computation of Results. 6. The modulus of rupture shall be calculated from the formula:

$$R = \frac{3}{2}\frac{wl}{bd^2}$$

where w = breaking load in pounds, l = length of span in inches, b = width of specimen in inches, and d = thickness of specimen in inches.

Reporting Results. 7. The average value of the three specimens cut parallel to the grain shall be reported as the modulus of rupture parallel to the grain, and the average value of the other three, as the modulus of rupture perpendicular to the grain. In case any specimen shows a value 25 per cent lower than the average of its group, it shall be examined for defects and if the low value appears to be due to an imperfection, the average of the other two shall be reported as the modulus of rupture of the group. All determinations shall be reported as information.

NOTE.—The following method of marking the specimens before testing is recommended:

By means of a tri-square the middle section and two end sections, 5 in. distant from the center, may be circumscribed. These marks serve as a guide to the operator in properly centering and aligning the specimen in the testing machine.

B. Modulus of Rupture and Modulus of Elasticity

TEST SPECIMENS

Size of Specimens.

8. The specimens shall be 12 by 4 in. in the direction of cleavage and $\frac{3}{8}$ in. in thickness.

Preparation of Specimens.

9. The slate should preferably be split to a thickness somewhat greater than $\frac{3}{8}$ in. and sawed into specimens 12 by 4 in. These should be finished on the faces with a hone or fine abrasive to plane, parallel surfaces. Where this is not practical the slate may be split to as near the desired thickness as possible and the specimens sawed therefrom.[1] One-half the specimens from each sample shall be cut with the length parallel to the grain and the other half with the length perpendicular to the grain.

Number of Specimens.

10. The number of specimens shall depend on the method of preparation as follows:

Hone-finished faces and edges	3 each way of grain
Cleavage faces and sawed edges	4 each way of grain

PROCEDURE

Drying, Measuring and Testing.

11. The specimens shall be dried, measured, and placed in a testing machine as described in Method *A* on Modulus of Rupture. A deflectometer, capable of measuring accurately to 0.001 in., shall be used to indicate the deflections at the center of the span. The load shall then be applied at the rate of about 100 lb. per minute and deflection readings recorded for each 50-lb. increment.[2] The load w at which the specimens break shall be recorded to the nearest 5 lb.

Computing Results.

12. The modulus of rupture, R, shall be calculated from the breaking load w from the formula:

$$R = \frac{3\,w\,l}{2\,bd^2}$$

where the symbols have the same meaning as in Method *A*.

---

[1] In testing slate shingles which have sheared edges, this type of specimen can be readily cut from the shingle with a hacksaw of the type in which the blade can be set at right angles to the frame.

[2] It is not ordinarily satisfactory to set the deflectometer to zero when there is no load on the specimen. The best practice is to put a small initial load on the specimen, as 10 lb., and set the deflectometer to zero for this load. Since it is only the slope of the stress-strain curve that is desired this initial load does not affect the final result.

The load-deflection readings shall be plotted on cross-section paper to a convenient scale and a straight line drawn to represent as nearly as possible the average of the points plotted.[1]

If this line does not pass through the zero point a corrected line shall be drawn through the zero point parallel to the stress-strain curve. The modulus of elasticity shall be computed from the coordinates of some convenient point on the corrected line by means of the formula:

$$E = \frac{W'l^3}{4\Delta bd^3}$$

where W' = the load ordinate of this point;
Δ = deformation ordinate of same;
l = length of span in inches;
b = the width of the specimen in inches; and
d = the thickness of the specimen in inches.

Reporting Results.

13. In general the average of the results obtained for the specimens prepared with the length parallel to the grain shall be reported as the modulus of rupture and modulus of elasticity parallel to the grain. Likewise the average results obtained on the specimens cut with the length perpendicular to the grain shall be reported as the modulus of rupture and the modulus of elasticity perpendicular to the grain. In case an individual determination differs by more than 25 per cent from the average of its group it may be disregarded in computing the average if there is evidence that the determination was of uncertain value, but all determinations shall be reported as information.

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[1] Slate does not ordinarily show a yield point in the stress-strain curve.

TENTATIVE METHODS OF TEST
FOR
DETERMINING THE INSULATING QUALITIES OF SLATE[1]

Serial Designation: D 273 - 27 T

This is a **Tentative Standard,** published for the purpose of eliciting criticism and suggestions, and as such is subject to annual revision.

ISSUED, 1927.

When it is desired to select slate for specific applications or when a routine factory or shop test is desired, either Method (*a*) or (*b*) may be used. These tests are of high sensitivity and are applicable to laboratory or routine testing at the plant using the slate for electrical purposes. Both Methods (*a*) and (*b*) shall be applied before the slate is drilled.

FACTORY OR LABORATORY TEST[2]

Method A:

Scope. 1. Method (*a*) covers the determination of the impedance leakage current flowing in the high voltage winding of the transformer by means of an ammeter in the low voltage winding.

Apparatus. 2. The apparatus shall consist of the following:

(*a*) *Transformer.*—A standard 10,000-volt portable testing transformer of 5 KVA. rating.

(*b*) *Ammeter.*—An ammeter having a full scale reading of 5 amperes.

(*c*) *Current Source.*—A source of 115 to 125 volt alternating current having a frequency of from 25 to 60 cycles and preferably of approximately sine-wave form.

(*d*) *Electrodes.*—Two electrodes of 4/0 copper wire with rounded ends and provided with suitable insulation for the protection of the operator.

Test Specimens. 3. The test specimens may be of any size and shall have all surfaces, including edges, sand-rubbed or hone finished.

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[1] Criticisms of these Tentative Methods are solicited and should be directed to Mr. D. K. Boyd, Secretary of Committee D-16 on Slate, Structural Service Bureau, Otis Building, Philadelphia, Pa.

[2] **The committee has been at work on the development of a quarry test, designed to make possible the selection at the quarry of slate suitable for electrical purposes, which it plans to include ultimately with the present methods.**

Procedure. 4. (*a*) The ammeter shall be connected in series with the low voltage side of the testing transformer and the exciting current noted. (This should be approximately 3 amperes for 25 cycles and 1 ampere for 60 cycles.)

(*b*) The high voltage side shall be connected for 5000 volts.

5. The leakage current, that is, the increase in current above the no-load exciting current of the transformer, shall be noted in the ammeter for the three following tests:

(*a*) The surfaces and edges of the slate shall be gone over with the electrodes not less than 2 in. apart.

(*b*) The slate shall be stood on edge on a sheet of metal. One electrode shall be placed in contact with the metal sheet and the other electrode moved over the surfaces and edges of the slate.

(*c*) The slate shall be laid on a sheet of metal with the surface making good contact. One electrode shall be placed in contact with the metal sheet and the other electrode moved over the upper surface of the slate.

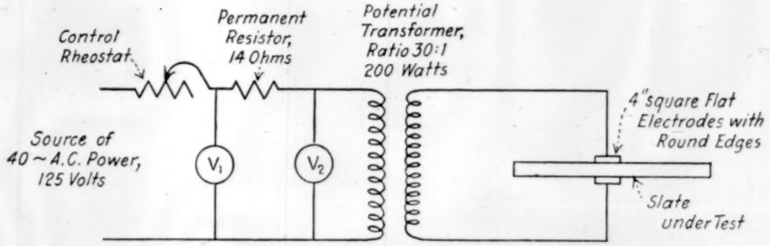
Control Rheostat
Permanent Resistor, 14 Ohms
Potential Transformer, Ratio 30:1 200 Watts
4" square Flat Electrodes with Round Edges
Source of 40 ~ A.C. Power, 125 Volts
V_1
V_2
Slate under Test

FIG. 1.—Diagram of Connections for Measuring Leakage Current Through Slate.

Method B:

Scope. 6. Method (*b*) covers the determination of the impedance leakage current flowing in the high voltage winding of the transformer or the specific ohmic impedance of the slate by reading two voltmeters in the low voltage circuit.

Apparatus. 7. The apparatus shall be connected as shown in Fig. 1 and shall consist of the following:

(*a*) *Transformer.*—A standard 30:1 potential transformer *PT* of 200 V. A. capacity.

(*b*) *Voltmeter.*—Two 150-volt alternating current voltmeters, V_1 and V_2.

(*c*) *Current Source.*—A source of 115 to 125 volt alternating current having a frequency of from 25 to 60 cycles and preferably of approximately sine-wave form.

(*d*) *Electrodes.*—Two padded electrodes 4 in. square so arranged as to clamp down and make intimate contact with directly opposite sides of the slate, and provided with insulated handles for the protection of the operator.

(*e*) *Rheostat.*—A variable rheostat, R_1, for controlling the voltage across the voltmeter, V_1.

(*f*) *Resistance.*—A fixed resistance, R_2, of 14 ohms.

Test Specimens.

8. The test specimens may be of any size or thickness which would be used for electrical purposes. They shall have the face and back sand-rubbed or hone finished.

Procedure.

9. The electrodes shall be clamped in place so that they come exactly opposite each other and exert a considerable pressure so as to reduce the contact resistance between the electrodes and the slate.

10. (*a*) With a reading of 110 volts held on voltmeter V_1, the voltage reading on voltmeter V_2, due to the voltage-drop through the fixed resistance, R_1, indicates the insulation value of the slate.

(*b*) As soon as a reading of voltmeter V_2 is obtained the electrodes shall be moved to another section of the slate. This shall be repeated until the entire surface of the slate has been covered.

(*c*) The reading of voltmeter V_2 shows great variation for low values of impedance and very little variation for high values.

NOTE.—This testing device can be safely used by an unskilled operator. The control circuit may be such that the placing of the electrodes on the slate is done by long insulating handles and the primary circuit of the transformer is open when the location of the electrodes is being changed. As the reading of voltmeter V_1 is held at a constant value, the scale of voltmeter V_2 may be marked in red for voltage values below the point predetermined as acceptable for electrical slate. If the needle is on the red portion of the scale when any section is being tested the slate shall be rejected.

11. For calibrating, a milli-ammeter or voltmeter of high resistance shall be inserted in series with the high voltage side of the transformer and the current flowing through the slate and the voltage across the slate determined for various values of readings on voltmeter V_2. The ohmic impedance shall be calculated from this data. A calibration curve for the apparatus shall be made by plotting ohmic impedance per square inch of electrode surface against readings of voltmeter V_2. It is necessary to test a considerable number of samples of slate of different insulation values in order to obtain a satisfactory calibration curve. After the apparatus is once calibrated, a very accurate measurement of the ohmic impedance of the slate may be obtained.

TENTATIVE METHODS OF TESTING ELECTRICAL PORCELAIN[1]

Serial Designation: D 116 – 27 T

This is a **Tentative Standard,** published for the purpose of eliciting criticism and suggestions, and as such is subject to annual revision.

ISSUED, 1921; REVISED, 1924, 1926, 1927.

Scope.

1. These tests are intended to apply to porcelain which is to be used for electrical insulating purposes.

TENSILE STRENGTH

Apparatus.

2. Any standard testing machine of suitable capacity may be used providing the error in the loading range does not exceed 1 per cent.

Test Specimens.

3. (*a*) The test specimens for this test shall be of the form and dimensions shown in Fig. 1.

(*b*) For wet-process porcelain, the test specimens shall be made from a column obtained by forcing the batch mixture through a die. Sections of the column, after thorough drying, shall be formed to the required shape with due allowance for shrinkage. During the firing, care shall be taken to maintain the axis perfectly straight.

(*c*) For cast porcelain, the specimens shall be cast in molds of calcined gypsum (plaster of Paris) having the required shape, due allowance being made for all shrinkages. None of the material except the fins shall be removed from the specimen.

(*d*) For dry-process porcelain, the specimens shall be formed by pressure into the required shape in metal molds with due allowance for all shrinkages.

Mounting of Specimens.

4. (*a*) Suitable grips for holding the specimen shall be self-aligning and shall grip the specimen over sufficient area and in a manner not to cause pinching near the minimum section nor local compression at the smaller ends of the metal grips. Grips designed for the purpose and found satisfactory are shown in Fig. 2. In principle they are arranged like gimbals or a universal joint used for maintaining a mariner's compass in position. A yoke allows a ring to swing about

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[1] Criticisms of these Tentative Methods are solicited and should be directed to Mr. T. S. Taylor, Secretary of Committee D-9 on Electrical Insulating Materials, Bakelite Corporation, 230 Grove St., Bloomfield, N. J.

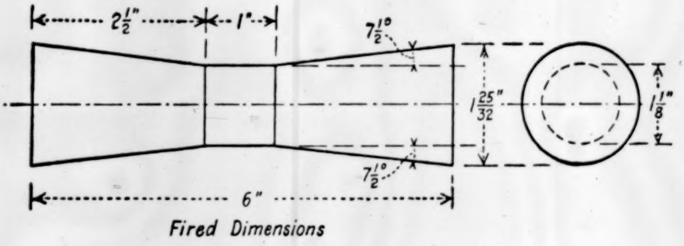
2 1/2"
1"
7 1/2°
1 25/32"
1 1/8"
7 1/2°
6"
Fired Dimensions

FIG. 1.—Test Specimen for Determining Tensile Strength of Porcelain.

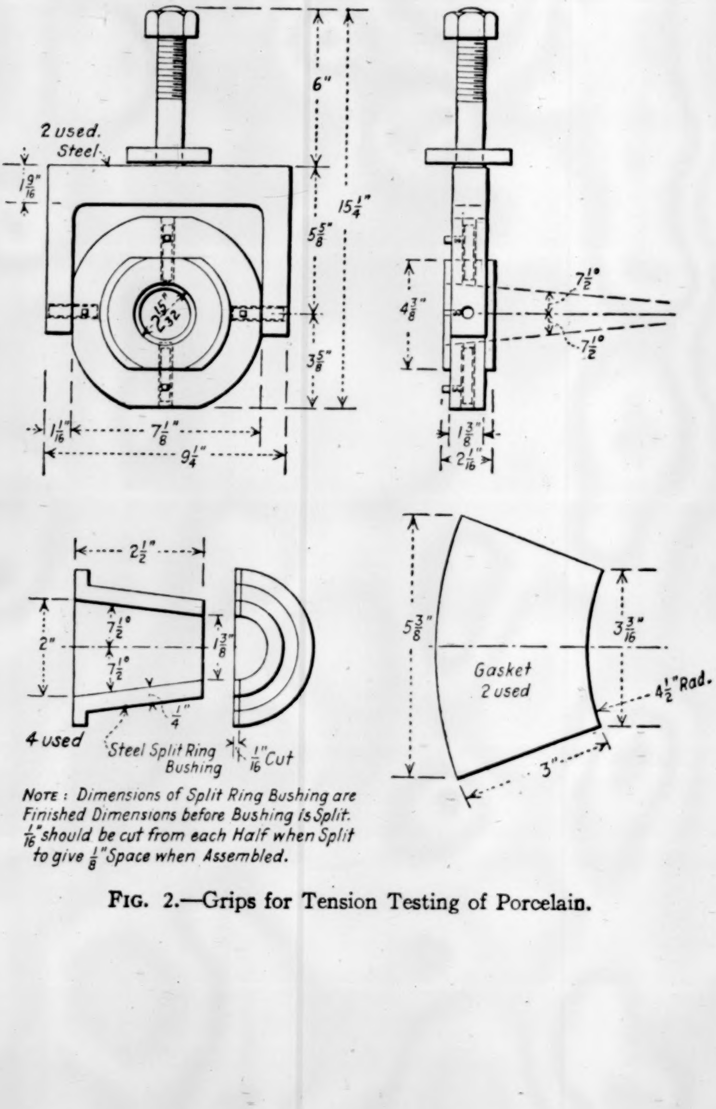
2 used.
Steel
1 9/16"
6"
15 1/4"
5 5/8"
2 15/32"
3 5/8"
1 1/16"
7 1/8"
9 1/4"
4 3/8"
7 1/2°
7 1/2°
1 3/8"
2 1/16"
2 1/2"
2"
7 1/2°
7 1/2°
1 3/8"
1/4"
4 used
Steel Split Ring Bushing
1/16" Cut
NOTE: Dimensions of Split Ring Bushing are Finished Dimensions before Bushing is Split. 1/16" should be cut from each Half when Split to give 1/8" Space when Assembled.
5 3/8"
3 3/16"
Gasket
2 used
4 1/2" Rad.
3"

FIG. 2.—Grips for Tension Testing of Porcelain.

a horizontal axis. A smaller ring is situated inside the first one but pivoted by means of pins in a plane perpendicular to the horizontal axis. The inner ring is conically shaped and holds the porcelain specimen in place with the aid of the split bushings. The two yokes are placed in the testing machine at right angles to each other.

(*b*) The test specimen shall be fitted with a compressible gasket around each conical end with the parallel edges nearly touching. Blotting paper or sheet lead $\frac{1}{32}$ in. thick has been found satisfactory. The gasket may be held in place, while assembling the test specimen in the grips, by a temporary clamp at the place of minimum section. After the specimen has been assembled in place ready for test, the temporary clamp shall be removed. The grips holding the test specimen in place in the testing machine are shown in Fig. 3. A disassembled view of the apparatus is shown in Fig. 4.

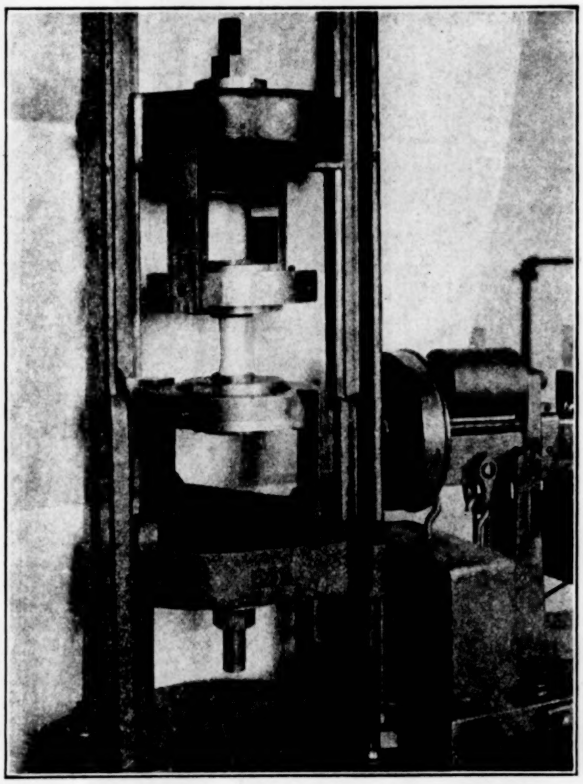

FIG. 3.—Grips and Test Specimens Assembled in Testing Machine in Tension Testing of Porcelain.

Procedure. 5. (*a*) Not less than five specimens shall be tested in the normal condition.

(*b*) The diameter of each specimen at the minimum section shall be measured with a micrometer graduated to 0.001 in. (0.025 mm.). The value of the diameter to be used in the calculation shall be the average of two measurements taken at right angles.

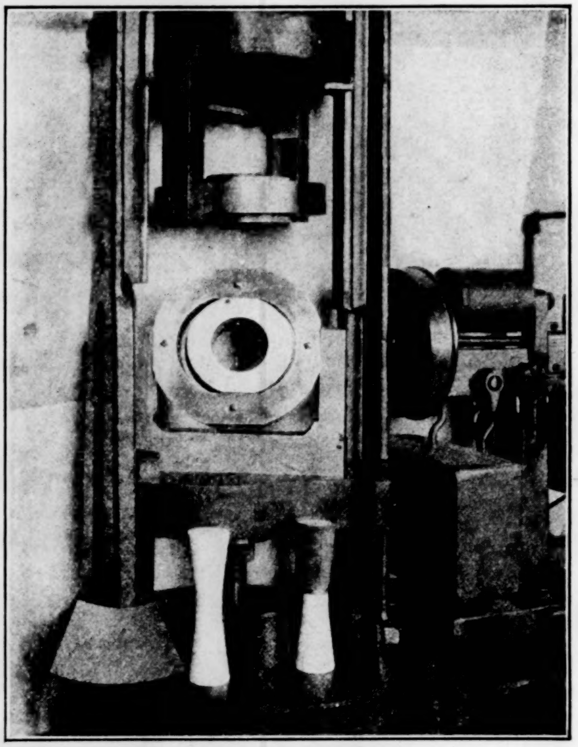

FIG. 4.—Apparatus for Tension Testing of Porcelain, Including Grips, Specimen, Split Ring and Blotting Paper Gasket.

(*c*) The speed of head of the testing machine shall be such that the load can be accurately weighed.

(*d*) The tests shall be made at a temperature of about 21° C. (70° F.).

(*e*) Results on specimens which do not break in the section of minimum cross-section shall be included, though the unit stress shall be calculated using the minimum cross-section. Any results whose deviation from the mean of the deviations is more than 3 times the mean of the deviations shall be discarded.

Report. 6. The report shall include the following:

(*a*) The breaking load of each specimen in pounds.

(*b*) The diameter of each specimen in inches at the place of break and at the minimum section.

(*c*) The tensile strength of each specimen in pounds per square inch.

(*d*) The average of the results given in Paragraph (*c*) and the percentage average deviation from the mean.

(*e*) A description of each fracture and the behavior of the material under load. The description of the fracture should tell whether the fractured area was totally or partially rough, and whether pin holes or other flaws were found.

NOTE.—An examination of the fracture of a normal specimen will show the entire area to consist of a very coarse granular surface, indicating that the entire area was subjected to tension and that the entire surface resisted it. In a specimen containing a pin hole or other flaw, the fracture will usually start near that flaw or pass through it. Part of the surface further away from the flaw will be granular, but the surface near the flaw will be much smoother. If the specimen is compressed at a narrow portion near one of the grips, the surface is again divided into two distinct areas, the area of tension and the area of shear, the latter radiating from the spot which was most under compression.

(*f*) The rate of application of the load.

(*g*) The name and rating of the machine used to make the tests.

(*h*) A curve sheet showing the tensile strength in pounds per square inch of each specimen, the first value being the lowest and each succeeding one the next higher.

COMPRESSIVE (CRUSHING) STRENGTH

Apparatus. 7. Any standard testing machine of suitable capacity may be used providing the error in the loading range does not exceed 1 per cent.

Test Specimens. 8. (*a*) The test specimens for this test shall be in the form of cylinders and shall be 1.125 in. (2.86 cm.) in length and 1.125 in. (2.86 cm.) in diameter.

(*b*) They shall be made as described in Section 3. The flat surfaces shall be made as smooth and parallel as possible before firing. After firing, the flat surfaces shall be ground smooth and parallel.

Procedure. 9. (*a*) Not less than five specimens shall be tested in the normal condition.

(*b*) A contact pad or cushion of blotting paper $\frac{1}{64}$ in. thick shall be placed between the upper and lower faces of the specimen and the self-aligning heads of the testing machine to equalize irregularities in the surfaces. Fresh cushions shall be used for each specimen.

(*c*) The diameter and length of each specimen shall be measured with a micrometer graduated to 0.001 in. (0.025 mm.). The value of the diameter to be used in the calculations shall be the average of two measurements taken at right angles.

(*d*) The speed of head of the testing machine shall be such that the load can be accurately weighed.

(*e*) The tests shall be made at a temperature of about 21° C. (70° F.).

Initial and Ultimate Failure. 10. Note shall be made of the load in pounds at initial failure but the value of the load in pounds at ultimate failure shall be determined and used in calculating the compressive (crushing) strength.

Report. 11. The report shall include the following:

(*a*) The load in pounds on each specimen at initial failure and the load in pounds at ultimate failure.

(*b*) The diameter and length of each specimen in inches.

(*c*) The compressive (crushing) strength of each specimen in pounds per square inch.

(*d*) The average of the results given in Paragraph (*c*) and the percentage average deviation from the mean.

(*e*) The behavior of the material under load.

(*f*) The rate of application of the load.

(*g*) The name and rating of the machine used to make the tests.

(*h*) A curve sheet showing the compressive strength in pounds per square inch of each specimen, the first value being the lowest and each succeeding one the next higher.

TRANSVERSE STRENGTH

Apparatus. 12. Any standard testing machine of suitable capacity may be used.

Test Specimens. 13. (*a*) The test specimens for the transverse strength test shall be in the form of cylinders and shall be 6 in. (15.2 cm.) in length and 1.125 in. (2.86 cm.) in diameter.

(*b*) They shall be made as described in Section 3.

Mounting of Specimens. 14. The specimen shall be supported on two steel wedge-shaped blocks with supporting edge rounded to 0.125 in. (3.175 mm.) radius. The supports shall be 5 in. (127 mm.) apart and the specimen shall be laid upon them with ½ in. (12.7 mm.) overlap at each end. The load shall be applied on top of the specimen at right angles to the specimen and midway between the supports by means of a wedge-shaped pressure piece (angle 45 deg.), the eegd of which is rounded on a 0.125 in. (3.175 mm.) radius.

Method. 15. (*a*) Not less than five specimens shall be tested in the normal condition.

(*b*) The diameter of each specimen shall be measured with a micrometer graduated to 0.001 in. (0.025 mm.). The value of the diameter to be used in the calculations shall be the average of two measurements taken at right angles at the middle of the specimen.

(*c*) The load shall be applied at that constant rate of speed which will permit the beam to be kept well balanced at all loads.

(*d*) The tests shall be made at a temperature of about 21° C. (70° F.).

Modulus of Rupture. 16. The modulus of rupture shall be calculated for each specimen as follows:

$$M = \frac{8\,PL}{\pi\, d^3}$$

where M = modulus of rupture;
P = load in pounds at rupture;
L = distance between supports in inches;
d = diameter of specimen in inches;
π = 3.1416.

Report. 17. The report shall include the following:

(*a*) The breaking load of each specimen in pounds.

(*b*) The diameter and length of each specimen in inches.

(*c*) The modulus of rupture for each specimen as calculated in Section 16.

(*d*) The average of the results given in Paragraph (*a*) and the percentage average deviation from the mean.

(*e*) A description of each fracture and the behavior of the material under load.

(*f*) The rate of application of the load.

(*g*) The name and rating of the machine used to make the tests.

(*h*) A curve sheet showing the transverse strength (modulus of rupture) for each specimen, the first value being the lowest and each succeeding one the next higher.

RESISTANCE TO IMPACT

Apparatus. 18. The test shall be made with an apparatus in which a weight of 1 lb. is raised $\frac{1}{2}$ in. and allowed to fall on the specimen. It is then raised 1 in. and allowed to fall again on the specimen. This is continued, the weight being raised and dropped through a distance increasing by increments of $\frac{1}{2}$ in. until the specimen is broken.

Specimen. 19. The test specimen described in Section 8 shall be used for impact tests.

Procedure. 20. (*a*) The test specimen shall be clamped in the base of the impact tester directly under the hammer. The stops shall be set to give a successively increasing rise of hammer by $\frac{1}{2}$-in. increments, the first height being $\frac{1}{2}$ in.

(*b*) The entire hammer shall weigh 1 lb.

(*c*) The test shall be continued until the specimen cracks.

(*d*) Not less than five specimens shall be tested in the condition in which they are received.

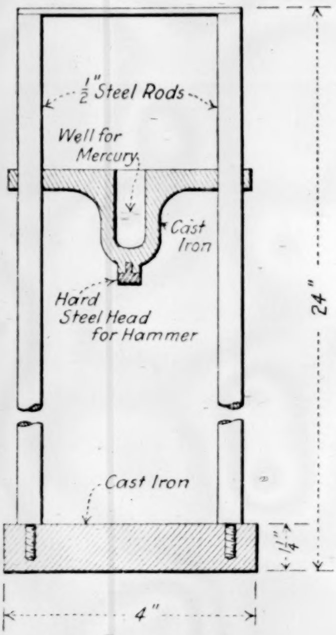

FIG. 5.

Report. 21. The report shall include the number of blows required to break each specimen, the energy of each blow in inch-pounds and the total energy in inch-pounds (that is, the sum of all blows).

NOTE.—The apparatus may be a simple hand-operated one constructed along the line of the one shown in Fig. 5 or a motor-operated machine where the weight is lifted and the distances are increased automatically.

DIELECTRIC STRENGTH

Apparatus. 22. The apparatus shall be as described in Section 14 of the Standard Methods of Testing Molded Insulating Materials (Serial Designation: D 48) of the American Society for Testing Materials.[1]

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[1] 1927 Book of A.S.T.M. Standards, Part II.

23. The specimen shall be a disk approximately 2 in. in diameter, the flat sides being made plane and parallel. The thickness of the specimen shall be 0.250 in. (6.35 mm.), 0.4 in. (10.16 mm.), 0.75 in. (19.05 mm.), or 1.0 in. (25.4 mm.). The thickness shall be within ± 10 per cent of these values. **Test Specimen.**

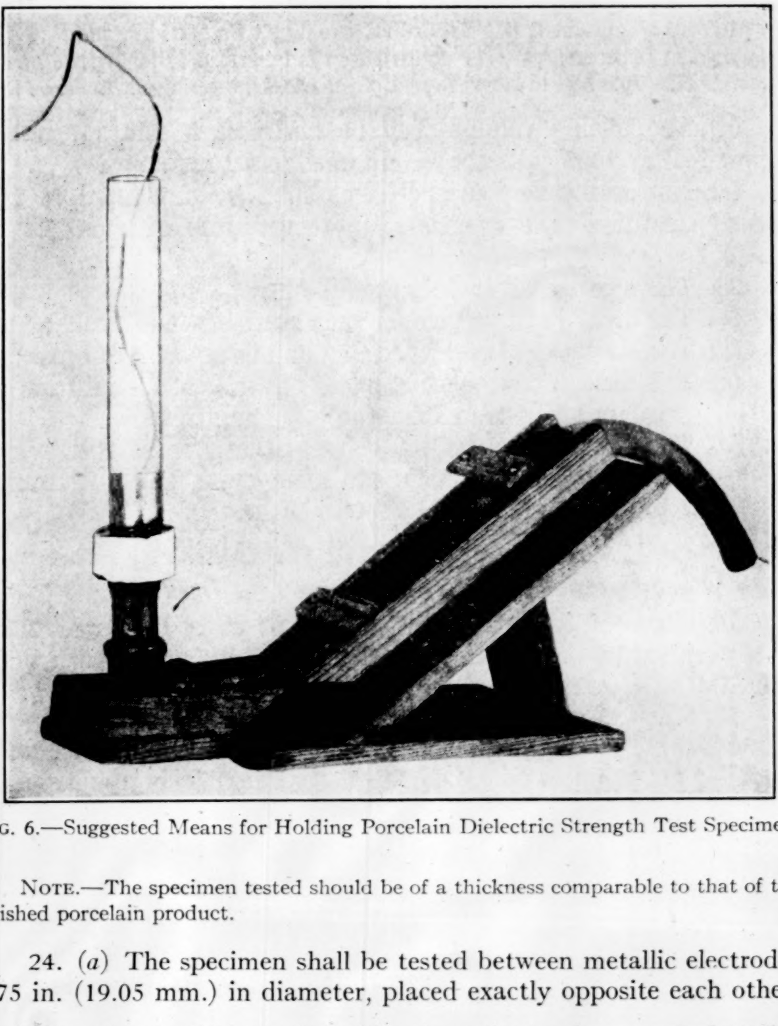

FIG. 6.—Suggested Means for Holding Porcelain Dielectric Strength Test Specimen.

NOTE.—The specimen tested should be of a thickness comparable to that of the finished porcelain product.

24. (*a*) The specimen shall be tested between metallic electrodes 0.75 in. (19.05 mm.) in diameter, placed exactly opposite each other. **Procedure.**

NOTE.—A suggested means for holding the specimen, using mercury electrodes, is shown in Fig. 6. This consists of a metal tube supported in a frame. The specimen is affixed to the metal tube using ordinary sealing wax, and a short glass tube is similarly affixed to the upper surface of the specimen.

In applying the sealing wax, one end of the tube is dipped about ⅜ in. (9.5 mm.) into a bath of molten wax. Upon removal, it is immediately pressed into place on the specimen and allowed to cool to room temperature. (If a film of wax covers the tube it should be broken before placing the tube on the specimen.) In order more thoroughly to smooth out the wax and seal the tube, the wax seal may be softened slightly with a fine moderate flame. The test specimen should never be heated when affixing the tubes, as the heat may set up strains in the porcelain specimen that will materially affect its properties.

Mercury is introduced into both tubes, avoiding entrapped air, and lead wires are placed in the mercury. The entire set-up is immersed in high-grade mineral insulating oil. It is best to have the ends of the tubes projecting above the oil level.

(*b*) The testing voltage shall be raised at a constant rate of approximately 1000 volts per second until puncture occurs.

(*c*) Not less than five specimens shall be punctured in their normal condition at a normal room temperature of about 20° C. (68° F.).

Report. 25. The report shall include the following:

(*a*) The breakdown voltage for each specimen in kilovolts;

(*b*) The thickness of each specimen in mils at point of break;

(*c*) The dielectric strength in volts per mil calculated from the values reported in Paragraphs (*a*) and (*b*);

(*d*) The average breakdown voltage, the average thickness of the specimen at break, and the average dielectric strength in volts per mil for the specimens tested.

RESISTANCE TO THERMAL CHANGE

(*A*) *Porcelain for Transmission Line Insulators.*

Apparatus. 26. The apparatus shall consist of a hot water bath maintained at a temperature of 100° C. (212° F.) and an ice water bath maintained at 0° C. (32° F.).

Specimens. 27. The test specimens shall be as shown in Fig. 6.

Procedure. 28. (*a*) The test specimen shall be immersed in the ice water bath for ten minutes and then transferred as quickly as possible to the hot water bath, and allowed to remain there for ten minutes. The specimen shall be transferred back to the cold water and the cycles continued until the specimen breaks.

(*b*) Not less than five specimens shall be tested.

Report. 29. Report the number of cycles necessary to cause fracture of each test specimen.

(*B*) *Porcelain for Spark Plugs and Heating Devices.*

Apparatus. 30. A furnace in which a temperature of 900° C. (1652° F.) can be obtained and any suitable testing machine for determining the transverse strength of small beams may be used.

31. The specimens shall be as described in Section 13. **Specimens.**

32. (*a*) One-half of not less than 12 specimens shall be taken and placed in the furnace. The rate of heating shall be so adjusted that the temperature reaches 900° C. (1652° F.) in two hours. The furnace shall then be allowed to cool at such a rate that room temperature is reached in four hours. **Method.**

(*b*) All specimens for transverse strength shall be tested by placing them on supports 5 in. apart and loading them at the center.

33. The report shall include the following: **Report.**

(*a*) The load in pounds or kilograms required to break each specimen not subjected to heat treatment, together with the average.

(*b*) The load required to break each specimen that was subjected to heat treatment, together with the average.

(*c*) The percentage loss of strength due to heat treatment calculated from the two averages.

POROSITY

(*A*) *Water Absorption.*

34. Any good chemical balance, a beaker of distilled water at normal room temperature of about 20° C. (68° F.) and an oven of any standard make capable of maintaining a uniform temperature at the desired point within ±5° C. shall be provided. **Apparatus.**

35. A single piece of porcelain shall be used weighing from 30 to 50 g. and with at least 50 per cent of the surface newly fractured. **Specimens.**

36. The specimen shall be dried for 24 hours at 120° C. (248° F.), cooled in a desiccator and weighed. The specimen shall then be totally submerged in the distilled water at room temperature (about 20° C.) and allowed to remain submerged for 100 hours. The water shall be boiled for approximately one hour during the first, twenty-fifth, forty-ninth and seventy-third hours. The specimen shall be removed at the end of the 100-hour period, the surface moisture carefully dried off with a clean, dry cloth and the specimen weighed. **Procedure.**

37. The report shall include the following: **Report.**

(*a*) The original weight of the specimen;

(*b*) The dry weight of the specimen;

(*c*) The dry weight of the specimen after immersion for 100 hours;

(*d*) The percentage of moisture content in each specimen as received and the percentage of moisture absorbed during 100 hours, taking the dry weight as 100 per cent, and the average where more than one specimen is tested.

(B) *Pore Volume*

Pore Volume. 38. The pore volume of porcelain shall be determined by measuring (at atmospheric pressure) the volume of air contained in a sample of porcelain of known volume.

Apparatus. 39. Any suitable apparatus based on the laws of gas expansion, which will accomplish the measurement called for in Section 38 may be used.

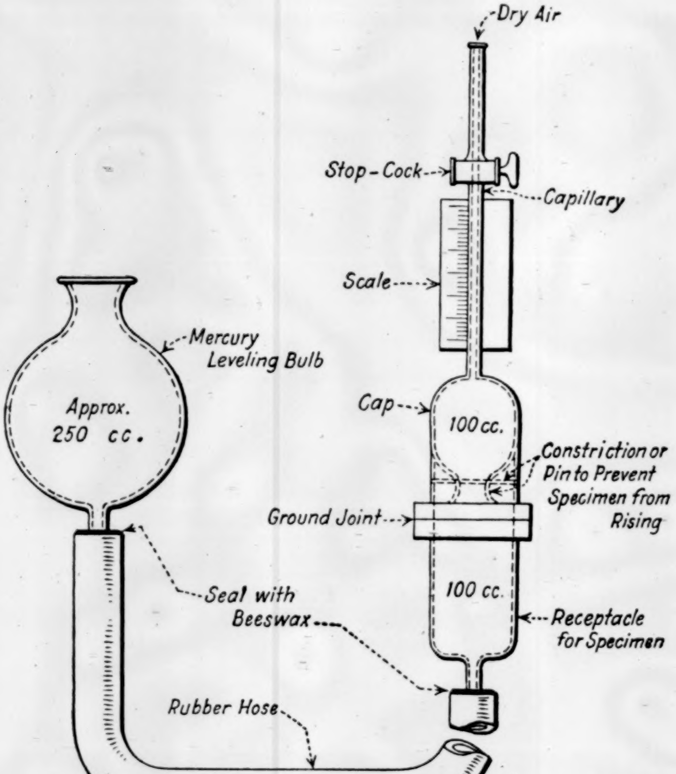
Dry Air
Stop-Cock
Capillary
Scale
Mercury Leveling Bulb
Approx. 250 cc.
Cap
100 cc.
Constriction or Pin to Prevent Specimen from Rising
Ground Joint
Seal with Beeswax
100 cc.
Receptacle for Specimen
Rubber Hose

FIG. 7.—Diagrammatic Sketch of Porosimeter.

The McLeod gage type of porosimeter is especially adaptable to this determination. This apparatus consists of a receptacle and cap fitted together by a ground air-tight joint. The cap is surmounted by a calibrated capillary tube and stop-cock. The specimen is placed in the receptacle and prevented from rising into the cap by means of a constriction or pin. The receptacle is connected by a glass or metal pipe at the bottom to a heavy rubber hose which in turn is connected to a glass leveling bulb. The total volume of the specimen receptacle and cap should be approximately 200 cc. Figure 7 shows a diagrammatic sketch of a McLeod gage-type porosimeter.

NOTE.—Suitable porosimeters of the McLeod gage type are: (1) glass apparatus of Washburn and Bunting;[1] (2) metal apparatus of Navias.[2]

Volume and Length of Capillary.—For porcelain of low-pore volume it is necessary to use a capillary of small diameter to read the volume of accumulated air accurately. Thus, for porcelain up to 1 per cent pore volume the effective volume of the capillary must be at least 0.5 cc. (for a specimen of 50 cc. volume). For porcelain having a higher pore volume than 1 per cent, either a longer capillary or a capillary of larger diameter is required.

Atmospheric Conditions.—It is essential that the determination be made using dry air. This may be provided by any suitable means.

Test Specimen.

40. The test specimen shall consist of two or more pieces of porcelain having a total volume of not less than 50 cc. At least 50 per cent of the surface of the parts used shall be newly fractured.

Procedure.

41. (*a*) The following procedure is based on the use of a McLeod gage type of porosimeter:

(*b*) The fractured pieces of porcelain shall be placed in the receptacle, the ground joint greased, and the cap secured in position so that the apparatus is air-tight.

(*c*) Before making determinations, any moisture entrapped on the inner surfaces of the porosimeter or which may be on the test specimen shall be removed. To do this, the leveling bulb shall be raised until the mercury in the capillary is above the stop-cock. The stop-cock shall then be closed and the leveling bulb lowered so that the test specimen is subjected to a vacuum for at least one minute. Any moisture inside the porosimeter then vaporizes and by again raising the leveling bulb the gas is collected in the capillary and shall be finally expelled by opening the stop-cock.

(*d*) Immediately after removing the moisture the leveling bulb shall be lowered, exposing the test specimen to the air for at least one minute. The leveling bulb shall again be raised until the mercury in the capillary is above the stop-cock. The stop-cock shall then be closed and the leveling bulb lowered so as to expose all the specimen to the vacuum for at least one minute. The air contained in the porcelain then expands into the evacuated space around and above the porcelain. The mercury bulb shall then be raised again and the air collected in the capillary tube. When the mercury surface in the leveling bulb is on a level with the mercury meniscus in the capillary the accumulated air in the capillary is at atmospheric pressure and its volume, v, shall be read. This shall be considered to be the pore volume.

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[1] Washburn and Bunting, *Journal*, Am. Ceramic Soc., Vol. 5, pp. 528–535 (1922).

[2] Navias, *Journal*, Am. Ceramic Soc., Vol. 8, pp. 816–821 (1925).

(*e*) Several determinations of the pore volume should immediately be made as described in Paragraph (*d*). The values of pore volume thus obtained should be practically equal, and their average may be taken as the pore volume of the specimen, v. Lack of agreement among these values may be traced to leaks or moisture in the apparatus.

NOTE.—To test for leaks in the apparatus: After taking a reading, expel all gas from the apparatus. Close the stop-cock. Raise and lower the leveling bulb several times. The level of the mercury in the capillary should rise to the stop-cock when the leveling bulb is raised.

(*f*) The total volume V, of the pieces of each specimen shall be obtained by any suitable method, measuring to the nearest 0.2 cc.

(*g*) Not less than five specimens shall be tested.

Percentage of Pore Volume.

42. The percentage of pore volume shall be calculated as the volume of gas contained in the total volume of porcelain:

$$\text{Percentage of pore volume} = \frac{v \times 100}{V}$$

where V = total volume of test specimen as determined in Section 41 (*f*); and

v = the pore volume as determined in Sections 41 (*d*) and (*e*).

Report.

43. The report shall include the following:

(*a*) The percentage of pore volume of each specimen, the average of these values, and the percentage average deviation from the mean;

(*b*) The total volume of each test specimen;

(*c*) The name and type of the apparatus used;

(*d*) The total volume of the specimen receptacle.

TENTATIVE METHODS OF TESTING SHEET AND TAPE INSULATING MATERIALS FOR DIELECTRIC STRENGTH[1]

Serial Designation: D 149 – 27 T

This is a **Tentative Standard,** published for the purpose of eliciting criticism and suggestions, and as such is subject to annual revision.

ISSUED, 1922; REVISED, 1923, 1924, 1926, 1927.

Scope. 1. These methods are designated to determine the dielectric strength of sheet and tape insulating materials except (*a*) rubber insulating tape, which should be tested in accordance with the Tentative Specifications for Rubber Insulating Tape (Serial Designation: D 119 – 27 T) of the American Society for Testing Materials,[2] and (*b*) adhesive tape for electrical purposes which should be tested in accordance with the Standard Specifications for Adhesive Tape for General Use for Electrical Purposes (Serial Designation: D 69) of the American Society for Testing Materials.[3]

Since the dielectric strength of sheet and tape materials is dependent upon the time of application of the electrical tension, two tests differing in time duration are included as *A*, Short-Time Dielectric Strength Test, and *B*, One-Minute Step-by-Step Dielectric Strength Test, respectively.

A third test, designated as an Endurance Dielectric Strength Test, is included under *C*. It shows the relative dielectric strength of different flexible sheet and tape insulating materials at high temperature when subjected to electrical tensions for relatively long periods.

It should be noted that the results obtained with the electrodes specified for sheet material will differ from those specified for tape material (Section 3) and will not be comparable because the apparent dielectric strength of thin materials varies with the area of the electrodes.

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[1] Criticisms of these Tentative Methods are solicited and should be directed to Mr. T. S. Taylor, Secretary of Committee D-9 on Electrical Insulating Materials, Bakelite Corporation, 230 Grove St., Bloomfield, N. J.

[2] See p. 1028.

[3] 1927 Book of A.S.T.M. Standards, Part II.

A. Short-Time Dielectric Strength Test

APPARATUS

High-Voltage Transformer.

2. (*a*) Any well-designed, high-tension transformer connected to an alternating current supply, having as nearly a true sine wave as possible, may be used. The transformer and the source of supply of energy shall be not less than 2 kva. for voltages of 50,000 volts or less, and not less than 5 kva. for voltages above 50,000 volts. The frequency shall not exceed 100 cycles per second.

(*b*) Regulation shall be so controlled that the high-tension testing voltage taken from the secondary of the testing transformer can be raised gradually from any point and in no case more than 500 volts at a step. The control may be made by generator field regulation, with an induction regulator, or with a variable ratio auto transformer. Any method of regulating the voltage is satisfactory which does not distort the wave more than 10 per cent from a sinusoidal shape.

(*c*) The voltage may be measured by any approved method which gives root-mean-square values, preferably by means of a voltmeter connected to a special voltmeter coil in the high-tension winding of the testing transformer, or to a separate step-down instrument potential transformer. A voltmeter on the low-tension side of the transformer is satisfactory, if the ratio of transformation does not change under any test condition. An electrostatic voltmeter properly calibrated in the high-tension circuit is also satisfactory. A spark gap may be used to check the readings at very high potentials.

(*d*) Some protection is desirable in the high-tension circuit of testing transformers where the potential is 25,000 volts or over, to prevent dangerous surges and limit the current when the test specimen is punctured. It is, however, desirable to have as much energy available as possible when puncture occurs. If impedance in the form of choke coils is used in series with the high-tension terminals, it should not be greater than that which will limit the high-tension current to double the normal rated current of the testing transformer.

When a spark gap is used, a non-inductive resistance of about one ohm per volt should be inserted in series with one terminal of the spark gap, to damp high-frequency oscillations at the time of breakdown and limit the current flow. This resistance shall be as near the gap as possible. If the test is made with one side grounded, this resistance shall be on the ungrounded side of the circuit, and if neither side is grounded, the resistance shall be inserted one-half on each side of the spark gap. Water tube resistors are preferable to carbon for this purpose, as carbon resistance may be materially decreased by the passage of current.

(*e*) The apparatus used and the method of measuring the voltage shall meet the requirements of the Standards of the American Institute of Electrical Engineers.

Electrodes.

3. The electrodes shall be of brass or copper with flat polished contact surfaces. For sheet material they shall be cylinders 2 in. (50.8 mm.) in diameter and 1 in. (25.4 mm.) in length with the edges rounded to a radius of $\frac{1}{4}$ in. (6.35 mm.). For tapes the electrodes shall be cylindrical rods $\frac{1}{4}$ in. (6.35 mm.) in diameter with edges rounded to a radius of $\frac{1}{32}$ in. (0.8 mm.) and the upper movable one shall weigh 0.1 lb. (45.4 g.) ± 0.005 lb. (2.3 g.).

TEST SPECIMENS

Test Specimens.

4. (*a*) The test specimens may be of any convenient size, but the total area of the specimens of one sample of material shall be sufficient to permit making at least ten satisfactory tests.

(*b*) The specimens shall be representative of the material to be tested, care being taken to select material which is free from abnormal defects such as blisters, wrinkles, cracks, etc.

PROCEDURE

Surrounding Medium.

5. The tests shall be made in air with the specimen at room temperature.

Condition of Electrodes.

6. The testing electrodes shall be kept clean and polished.

Position of Electrodes and Specimen.

7. The electrodes shall be self-aligning, and shall be placed exactly opposite one another with the specimen in a horizontal plane between them.

8. The edges of tapes shall be clamped between blocks of insulating material under a pressure of approximately 100 lb. per sq. in. to prevent flashover occurring before puncture.

NOTE.—In the Appendix are shown two different devices which have been found satisfactory for these tests.

Application of Voltage.

9. Starting at zero, the voltage shall be increased uniformly to breakdown at a rate of 0.5 kilovolt per second, except that if breakdown occurs at this rate in less than 40 seconds, the rate shall be decreased so that breakdown will occur in not less than 40 seconds. If the material fails at less than 5 kilovolts, the minimum time shall be reduced from 40 seconds to 20 seconds.

Number of Tests.

10. Ten tests shall be made and the average of these ten puncturing voltages shall be taken.

Thickness.

11. The thickness of the specimen shall be measured at each puncture, using a ratchet micrometer graduated to 0.001 in. and having a circular foot not less than 0.240 in. nor more than 0.260 in. in diameter.

Report. 12. The report shall include the following:

(*a*) The thickness of the specimen at each puncture;

(*b*) Total volts and volts per mil of thickness at each puncture;

(*c*) The average, maximum and minimum volts at puncture per mil of thickness for each sample;

(*d*) The room temperature;

(*e*) The relative humidity, in per cent;

(*f*) The duration of the test.

B. One-Minute Step-by-Step Dielectric Strength Test

APPARATUS

Apparatus. 13. The apparatus shall consist of the high-voltage transformer and the electrodes specified in Sections 2 and 3.

TEST SPECIMENS

Test Specimens. 14. The test specimens shall be as specified in Section 4.

PROCEDURE

Surrounding Medium. 15. The tests shall be made in air with the specimen at room temperature.

Condition of Electrodes. 16. The testing electrodes shall be kept clean and polished.

Position of Electrodes and Specimen. 17. The electrodes shall be self-aligning, and shall be placed exactly opposite one another with the specimen in a horizontal plane between them.

18. The edges of tapes shall be clamped between blocks of insulating material under a pressure of approximately 100 lb. per sq. in. to prevent flashover occurring before puncture.

NOTE.—In the Appendix are shown two different devices which have been found satisfactory for these tests.

Application of Voltage. 19. A voltage shall be applied which is equal to 40 per cent of the breakdown voltage obtained in the short-time test to the nearest 1000 volts (or 500 volts with low voltages). The voltage shall then be increased by 10 per cent of the initial value until failure occurs, the voltage being held at each step for one minute. When changing from one step to a higher step, the voltage shall be increased to the required value within 10 seconds.

Number of Tests. 20. Five tests shall be made and the average of these five puncturing voltages shall be taken.

Thickness. 21. The thickness of the specimen shall be measured at each puncture, using a ratchet micrometer graduated to 0.001 in. and having a circular foot not less than 0.240 in. nor more than 0.260 in. in diameter.

Report. 22. The report shall include the following:

(*a*) The thickness of the specimen at each puncture;

(*b*) Total volts and volts per mil of thickness at each puncture;

(*c*) The average, maximum and minimum volts at puncture per mil of thickness for each sample;

(*d*) The room temperature;

(*e*) The relative humidity, in per cent;

(*f*) The duration of the test;

(*g*) The value of the initially applied voltage and the value of the voltage at each step.

C. Endurance Dielectric Strength Test

APPARATUS

Apparatus. 23. The apparatus shall consist of the high-voltage transformer specified in Section 2.

Test Specimen. 24. (*a*) The specimens shall be made by wrapping the material, in tape form with one-quarter lap, one-half lap, butt jointed or as sheets, on brass tubes. The tubes shall be, for sheets and for tape up to $1\frac{1}{2}$ in. in width, about 36 in. in length and 1 in. in outside diameter. For tapes wider than $1\frac{1}{2}$ in., the tubes shall be 2 in. in outside diameter. The sample shall be built up to the desired thickness, simulating practical conditions, winding all layers of tape in the same direction.

(*b*) A smooth layer of metal foil shall then be wrapped over the insulation for a distance of 24 in., leaving 6 in. of insulation uncovered at each end of the tube. The metal foil shall be bound in place with a wrapping of adhesive tape and shall extend the full length of the tube in order to protect the insulation at the end from corona discharge.

(*c*) A thermocouple shall be applied to the metal foil near the center of the tube and held in place by the adhesive tape.

PROCEDURE

Position of Specimen. 25. The specimen shall be mounted in an oven and a temperature of 100° C. (212° F.) maintained during the test. Provision shall be made for so mounting the specimen that the tube may be connected to the high voltage side of the circuit with the metal foil sheath and thermocouple connected to ground.

Application of Voltage. 26. A voltage equal to 10 per cent of the breakdown voltage (to the nearest kilovolt) obtained in the short-time test (Test *A*) shall be applied and maintained for 30 minutes. The voltage shall then be increased by steps of 20 per cent of the initial value until puncture occurs, the voltage being held at each step for 30 minutes.

Temperature Readings. 27. The temperature of the sample as indicated by the thermocouple shall be observed at intervals during the test and recorded at the end of each 30-minute period. It will be found that the temperature rises gradually until just before breakdown when the temperature increases rapidly. During this latter period, temperature readings shall be recorded at frequent intervals.

Report. 28. (*a*) The results shall be plotted using time, expressed in hours, as abscissas, and temperature, in degrees Centigrade, as ordinates. In addition to time as abscissas, the values of applied kilovolts shall be indicated since the value of kilovolts increases uniformly with time. The significant values to be taken from the curve and reported are:

(1) Duration of test;
(2) Breakdown voltage;
(3) Temperature of specimen at breakdown;
(4) Rate of temperature rise during test.

(*b*) The report shall also include a description of the specimen and its preparation, the thickness of the insulation and the number of layers of insulation.

APPENDIX

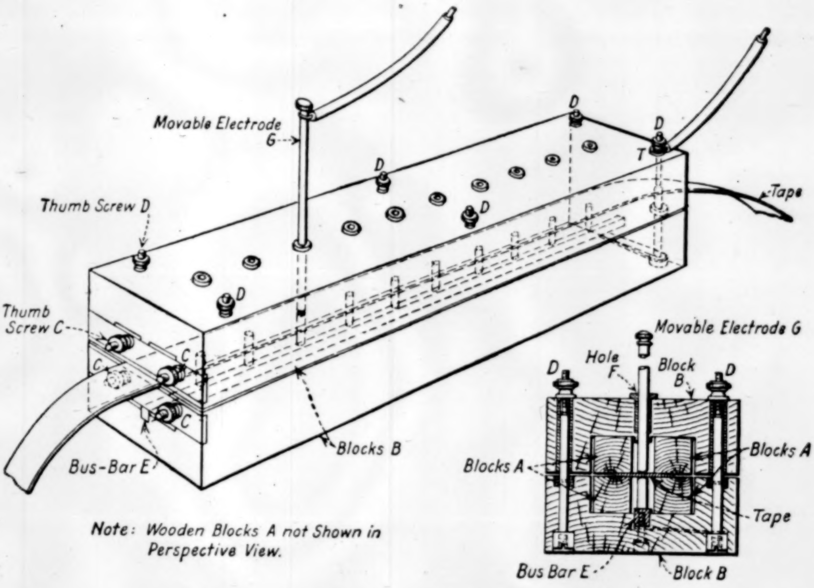
Figure 1 shows the multiple electrode form of tape tester. In this type, a strip of tape is held between four impregnated wooden blocks, *A*, which are in turn held in place in the two main blocks, *B*, by means of the thumb screws *C* in the ends of the blocks *A*. The blocks *A* are wound butt jointed with 1-in. varnished cloth tape. The whole device is clamped tightly together by the six thumb screws *D*.

There are ten lower electrodes which are fixed to a common bus-bar, *E*. The upper electrode, *G*, is movable and may be inserted into any of the bushed holes *F* which serve to align the upper electrode with the corresponding lower electrode. Voltage is applied between the upper and lower electrodes by direct connection to the upper electrode and by connection to the common bus-bar *E* through the thumb-screw terminal *D* marked *T*. The electrodes are cylindrical brass rods $\frac{1}{4}$ in. (6.35 mm.) in diameter with edges rounded to a radius of $\frac{1}{32}$ in. (0.8 mm.). The weight of the upper electrode is 0.1 lb. (45.4 g.).

After the tape is secured in position, the test is made by moving the upper electrode successively from hole to hole until ten punctures have been obtained.

As more or less carbon is formed during tests, the successful operation of this device depends upon keeping the parts clean. The electrodes should be cleaned with very fine emery paper, being careful not to change their form. The blocks *A* should be rewound from time to time with new varnished cloth tape.

Referring to Fig. 2 (*a*), the tape is held between two pieces of fiber, *A*, which, in turn, are held between two impregnated wood blocks, *B*, held in brass bases, *C*. The blocks are pressed together by a spring, *D*, which is compressed by the latch handle, *E*, through a rounded pin, *F*, fitting into a cup-shaped cap, *G*. When the handle is released, the blocks are spread apart by two light springs.

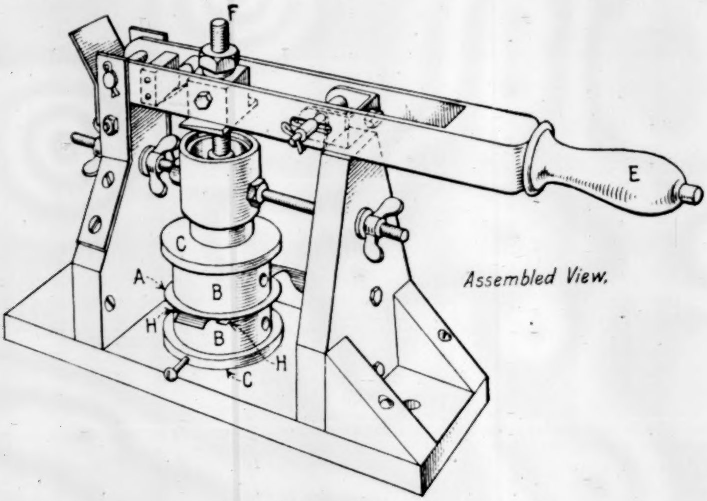

Movable Electrode G
D
D
T
Tape
Thumb Screw D
D
D
D
Thumb Screw C
C
C
C
C
Bus-Bar E
Blocks B
Movable Electrode G
Hole F
Block B
D
D
Blocks A
Blocks A
Tape
Bus Bar E
Block B

Note: Wooden Blocks A not Shown in Perspective View.

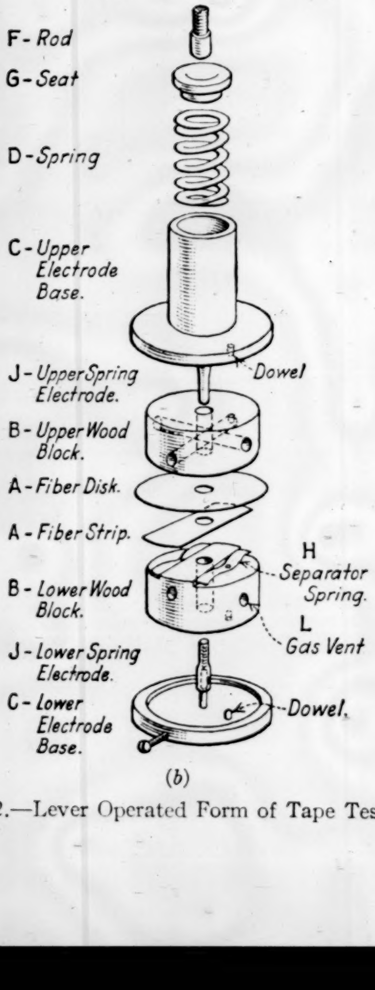
FIG. 1.—Apparatus for Dielectric Strength Test on Tape.

H, mounted on the face of the lower block. The electrodes, *J*, consist of hollow rods, fitted with very light internal springs, *K*, which hold the ends against the tape during the test. Vents, *L*, relieve any gas pressure which may develop when puncture occurs.

After considerable use, a leakage path will develop along the surface of one of the blocks and re-surfacing becomes necessary. This condition is avoided by using fiber disks as indicated in Fig. 2 (*b*). These disks are easily removed and replaced as necessary.


F
E
C
A
B
C
H
B
H
C
Assembled View.

(*a*) Assembled View.


F - Rod
G - Seat
D - Spring
C - Upper Electrode Base.
Dowel
J - Upper Spring Electrode.
B - Upper Wood Block.
A - Fiber Disk.
A - Fiber Strip.
H
Separator Spring.
B - Lower Wood Block.
L
Gas Vent
J - Lower Spring Electrode.
C - Lower Electrode Base.
Dowel.

(*b*)

FIG. 2.—Lever Operated Form of Tape Tester.

TENTATIVE METHODS OF TESTING ELECTRICAL INSULATING MATERIALS FOR POWER FACTOR AND DIELECTRIC CONSTANT AT FREQUENCIES OF 100 TO 1500 KILOCYCLES[1]

Serial Designation: D 150 - 27 T

This is a **Tentative Standard,** published for the purpose of eliciting criticism and suggestions, and as such is subject to annual revision.

ISSUED, 1922; REVISED, 1923, 1927.

1. These methods provide for the determination of the power factor and dielectric constant of solid electrical insulating materials at frequencies of 100 to 1500 kilocycles. **Scope.**

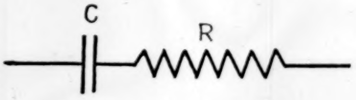


FIG. 1.—Equivalent Series Circuit.

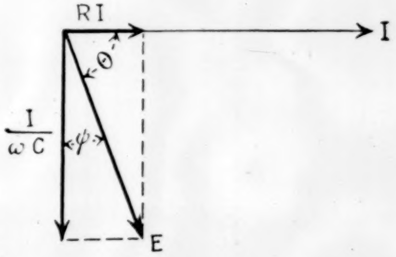


FIG. 2.—Vector Diagram for Equivalent Series Circuit.

DEFINITIONS

2. *Power Factor.*—The power factor of an insulating material is the ratio of the total power loss (watts) in the material to the product of voltage (volts) and current (amperes) in a capacitor in which that material is the dielectric. For the purpose of these methods the power factor shall be expressed in per cent. **Power Factor.**

3. *Dielectric Constant.*—The dielectric constant of an insulating material is the ratio of the capacitance of a capacitor in which that material is the dielectric to the capacitance of a similar capacitor in which the dielectric is a vacuum. (For practical purposes air dielectric is equivalent to a vacuum.) **Dielectric Constant.**

4. *Loss Factor.*—For the purpose of these methods the loss factor of an insulating material is the product of its power factor in per cent and its dielectric constant. **Loss Factor.**

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[1] Criticisms of these Tentative Methods are solicited and should be directed to Mr. T. S. Taylor, Secretary of Committee D-9 on Electrical Insulating Materials, Bakelite Corporation, 230 Grove St., Bloomfield, N. J.

THEORY OF TEST

Power Factor.

5. (*a*) *Series Notation.*—Any insulating material between two electrodes constitutes a capacitor. Such a physical capacitor may be represented by a capacitance C and a resistance R in *series* as shown in Fig. 1. The resistance R is called the equivalent series resistance and the capacitance C is called the equivalent series capacitance of the capacitor. For sine-wave voltage and current the vector relations are as shown in Fig. 2. The power factor is:

$$\text{Power Factor} = \cos\theta = \sin\Psi = \sin\tan^{-1} R\omega C$$

where R = the resistance in ohms;
ω = 2π times the frequency in cycles; and
C = the capacitance in farads.

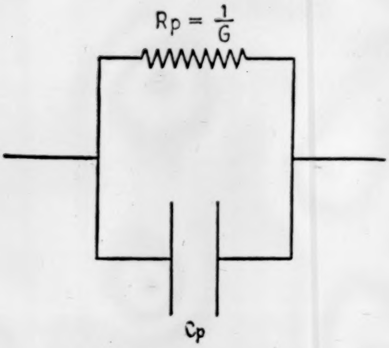

FIG. 3.—Equivalent Parallel Circuit.

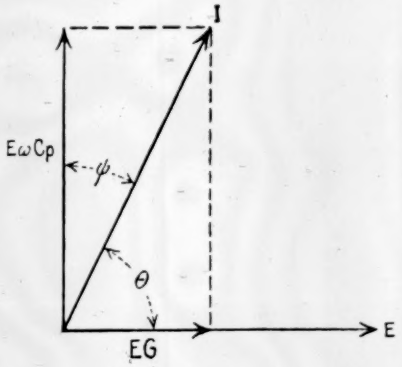

FIG. 4.—Vector Diagram for Equivalent Parallel Circuit.

Since, for small angles the sine is substantially equal to the tangent, the power factor equals $R\omega C$, approximately. This is correct to closer than 0.5 per cent of the power factor value for power factors up to 0.1 or 10 per cent. Where R is expressed in ohms, C in micro-microfarads, the frequency, f, in kilocycles, and the power factor in per cent, this expression becomes:

$$\text{Power Factor in per cent} = 6.28\, RCf \times 10^{-7}$$

The power factor is, therefore, determined by measuring the values of R and C. This may be done by the Substitution Method as described in Sections 14 and 15.

(*b*) *Parallel Notation.*—A physical capacitor may also be represented by a capacitance C_p and a resistance R_p in *parallel* as shown in Fig. 3. The resistance R_p is called the equivalent parallel resistance and the capacitance C_p is called the equivalent parallel capacitance of the capacitor. For sine-wave voltage and current the vector relations are as shown in Fig. 4. For this notation the power factor is:

$$\text{Power Factor} = \cos\theta = \sin\Psi = \sin\tan^{-1}\frac{G}{\omega C_p}$$

where G = the conductance in *mhos;*

ω = 2π times the frequency, in cycles; and

C_p = the capacitance in farads.

Making the same approximations as in Paragraph (*a*), the power factor for practical purposes is taken as $\frac{G}{\omega C_p}$. Where G is expressed in micro-mhos, the frequency, f in kilocycles, C_p in micro-microfarads, and the power factor in per cent, this expression becomes:

$$\text{Power Factor in per cent} = 1.59\frac{G\,10^4}{fC_p}$$

It will be seen that G and C_p determine the power factor. They may be measured by the Bridge Method as described in Sections 19 and 20.

The equivalent series capacitance C as determined by the Substitution Method, Sections 14 and 15, and the equivalent parallel capacitance C_p as determined by the Bridge Method, Sections 18 and 19, are not identical; but for power factors up to 10 per cent they are equal to within 1 per cent. Either value may be used in calculating the dielectric constant.

Dielectric Constant.

6. The dielectric constant K may be computed from the relation:

$$\text{Dielectric constant } K = \frac{(C - C_e)t}{0.0885A}$$

where t = the average thickness of dielectric between electrodes, in centimeters;

A = the contact area of either of the equal electrodes in square centimeters;

C = the measured capacitance in micro-microfarads;

C_e = the edge correction obtained from the curve in Fig. 5.[1]

The determination of C_e requires a knowledge of the approximate value of K which can always be obtained by making a preliminary calculation, neglecting C_e in the above formula. For thickness t, in inches, and area A, in square inches, the above formula becomes:

$$K = \frac{(C - C_e)\,t}{0.224\,A}$$

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[1] For details of the determination of the edge correction, see E. L. Hoch, *Bell System Journal*, Vol. V, pp. 555-572c, October, 1926.

Loss Factor.

7. The total power loss per unit volume of insulating material for a stated frequency, voltage gradient, and temperature, is proportional to the product of the power factor in per cent and dielectric constant. Therefore, the loss factor is defined as:

Loss Factor = Power Factor in per cent × Dielectric constant K

TEST SPECIMENS

Molded or Sheet Materials.

8. (*a*) For testing molded or sheet materials the test specimen shall be either a disk 6 in. (15.24 cm.) in diameter or a square 6 in. (15.24 cm.) on a side. The thickness shall preferably not be less than 0.1 in. (0.254 cm.) nor more than 0.3 in. (0.762 cm.). The thickness shall be uniform to ±5 per cent, and the surfaces shall be smooth and free from irregularities. Other thicknesses may be used where it is desired to test materials of the various thicknesses in commercial use. In any case, the capacitance of the specimen shall preferably not be less than 100 micro-microfarads.

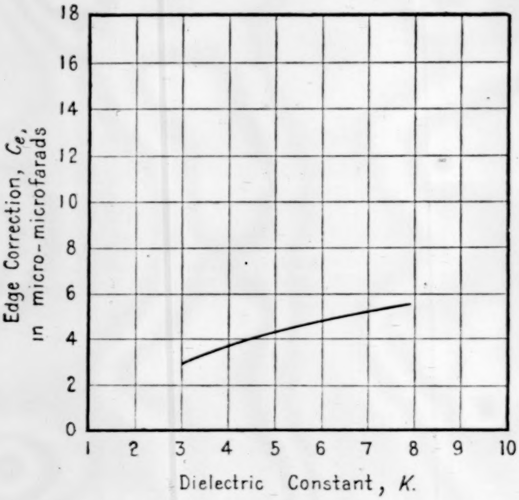

FIG. 5.—Edge Correction Curve for 4.5-in. Diameter Electrodes.

Insulating Films.

(*b*) For testing films of insulating varnish, lacquer, or paints, the test specimen shall be prepared as specified for the dielectric strength tests in the Appendix to the Tentative Methods of Testing Insulating Varnishes (Serial Designation: D 115 – 26 T) of the American Society for Testing Materials.[1] The copper or brass plate shall be one capacitor plate, and tin-foil the other. Both varnish films may be tested individually.

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 26, Part I, p. 1002 (1926); also 1927 Book of A.S.T.M. Tentative Standards, p. 569.

Conditioning of Test Specimens.

9. Before the specimens are tested, they shall be kept for 48 hours under uniform atmospheric conditions. Unless otherwise specified, these conditions shall be a relative humidity of 60 per cent and a temperature of 20 to 30° C. A satisfactory method of maintaining constant humidity is given in Section 12 of the Tentative Methods of Test for Surface Resistivity and Volume Resistivity of Solid Insulating Materials (Serial Designation: D 257 – 26 T) of the American Society for Testing Materials.[1]

Electrodes.

10. (*a*) The electrodes shall consist of tin or lead-foil disks 4.5 in. (11.43 cm.) in diameter and approximately 0.001 in. or 0.002 in. (0.025 or 0.050 mm.) in thickness. They shall be applied to the surface of the specimen and shall be accurately centered with respect to each other and approximately with respect to the specimen. A very thin coating of petrolatum shall be used as an adhesive.

(*b*) For testing materials of thickness less than 0.1 in. (0.254 cm.), such as thin-sheet insulating materials and films of insulating varnish and lacquer, the electrode area may be adjusted to give any convenient capacitance above 100 micro-microfarads. When calculating the dielectric constant of such materials, the edge correction should be omitted.

PROCEDURE

Method.

11. (*a*) The method of measurement may be either the substitution method as described in Sections 12, 13, 14 and 15, or the Bridge method as described in Sections 16, 17, 18, 19 and 20.

Measurements.

(*b*) The power factor and dielectric constant of at least two specimens shall be measured at such frequencies as may be mutually agreed upon between the supplier and the purchaser. Unless otherwise agreed upon the frequencies shall be approximately 100 kilocycles and 1000 kilocycles.

A. Substitution Method

APPARATUS

Generating Circuit.

12. *Oscillator.*—The generating circuit for the Substitution Method shall consist of an oscillator (preferably a vacuum tube) which is the power source. This oscillator shall be designed so as to be easily adjustable over a range of frequencies from 100 to 1500 kilocycles, and shall have a power rating sufficient to prevent any reaction on frequency or voltage output when coupled to the measuring circuit.

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 26, Part I, p. 1059 (1926); also 1927 Book of A.S.T.M. Tentative Standards, p. 642.

The oscillator output shall be of approximately sine-wave form, having not more than 5-per-cent harmonic components. The oscillator shall be well shielded. The entire apparatus shall be installed in a well-shielded room or so located as to be free from interference.

Measuring Circuit.

13. The measuring circuit is shown in Fig. 6 and shall consist of the following parts:

Coupling Coils.—Several coupling coils so designed as to tune over the required frequency range to within 1 per cent of the frequency desired. For convenience in tuning, an adjustable air capacitor of about 0.001 micro-farads capacity (tuning capacitor) may be connected across the coupling coil. This tuning capacitor should be of the same sensitivity of adjustment as the standard air capacitor, but no calibration is necessary.

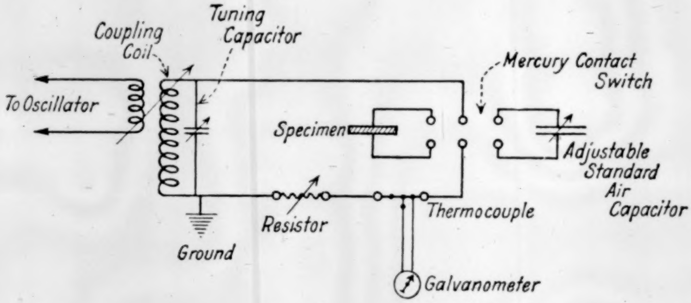

FIG. 6.—Measuring Circuit Diagram for Determination of Power Factor and Dielectric Constant by the Substitution Method.

Capacitor.—An adjustable standard air capacitor having a capacitance of about 0.001 microfarad capable of being read to 0.5 micro-microfarad. This capacitor shall be calibrated for capacitance and power factor over the required frequency range.

Switch.—A special high-frequency switch of the mercury contact type having mercury cups mounted on Pyrex or quartz tubes 4 to 6 in. (10 to 15 cm.) in length. This switch shall be a double-pole, double-throw, with copper switch blades well amalgamated with mercury.

Thermocouple Galvanometer.—The thermocouple shall have a low heater resistance, preferably less than 2 ohms, and be sufficiently sensitive for use with a suitable galvanometer. The galvanometer shall be of low resistance and short period and shall be operated critically damped. It shall have a sensitivity of approximately 120 mm. per micro-ampere at a scale distance of 1 meter.

Resistors.—Several resistors made of short, straight lengths of non-magnetic resistance wire (advance or manganin is preferable) sealed into glass tubes (which may be evacuated if desired). These resistors shall all have approximately the same length. For most work, 30 resistors to cover a range of 0.2 to 60 ohms will suffice. When resistance values higher than 60 ohms are required, a 3-dial 1000-ohm non-reactive decade box may be used.

METHOD

Operation.

14. With the specimen connected to the measuring circuit through the mercury contact switch, the circuit shall be tuned to approximately the desired frequency by proper selection of the coupling coil. The circuit may be brought into exact resonance by adjusting the frequency of the oscillator, or by means of the tuning capacitor if the latter is used. Resonance is indicated by maximum deflection of the galvanometer. The coupling to the oscillator shall be varied at the same time so that with no resistance inserted in the measuring circuit, approximately a two-third scale deflection of the galvanometer is obtained.

The adjustable standard air capacitor and a resistor shall then be substituted for the specimen. The resistance should be so chosen that when the measuring circuit is tuned to resonance by adjusting the standard air capacitor, a maximum deflection will be obtained on the galvanometer which is approximately the same as that previously produced by the specimen. Four resistors shall then be chosen having resistance values such that when inserted in the circuit, two will give deflections above and two below the deflection produced by the specimen. The deflections obtained with these four resistors shall be plotted against their resistance values. From this curve the equivalent series resistance R of the specimen shall be obtained by reading the value of resistance corresponding to the deflection produced by the specimen and adding to it the value of the resistance of the standard capacitor at the capacitance and test frequency used.

When a decade resistor is used, the procedure is the same as above except that it is sufficient to adjust the resistor to obtain a deflection equal to that produced by the specimen. The equivalent series resistance R is then equal to the dial reading of the resistance box plus the resistance of the standard air capacitor at the capacitance and test frequency used.

The capacitance reading of the standard air capacitor corrected for lead capacitance is the equivalent series capacitance C of the specimen.

The frequency shall be determined after the final tuning.

Calculations. 15. Calculations for power factor shall be made as described in Section 5 (*a*). Calculations for dielectric constant and loss factor shall be made as described in Sections 6 and 7, respectively.

B. Bridge Method

APPARATUS

Generating Circuit. 16. The generating circuit for the Bridge Method shall be the same as for the Substitution Method as described in Section 12.

NOTE.—The oscillator does not need to be of as high a power output for the Bridge Method as for the Substitution Method.

Measuring Circuit. 17. The measuring circuit is shown in Fig. 7 with necessary shielding as indicated, and shall consist of the following parts:

Balanced Resistors.—One pair of balanced non-reactive resistors or ratio arms, *AB* and *BC*, each of approximately 250 ohms resistance, and enclosed in an electrostatic shield as shown in Fig. 7. These arms shall be balanced for resistance to within 0.05 of 1 per cent, and for reactance to within 0.1-micro-microfarad equivalent parallel capacitance.

Adjustable Resistors.—Two non-reactive adjustable resistors each shielded as shown, for use in the *AD* and *CD* arms of the bridge. The *CD* arm resistor shall comprise two 1000-ohm steps. The *AD* arm resistor shall be a four-dial decade box having steps of 0.1, 1, 10, and 100 ohms, with an additional 1000-ohm step. Precision type, high-frequency commercial resistances are satisfactory for use in these resistors.

Differential Air Capacitor.—One differential air capacitor of 500-micro-microfarad capacitance, total variation. For convenience it is desirable to provide a vernier capacitor adjustable to 0.01 micro-microfarad. These capacitors shall be calibrated to read the capacitance inserted in the *CD* arm.

Input Transformer.—One shielded input transformer[1] adapted to the connection of a 250-ohm impedance to the oscillator.

Detector Circuit. 18. The detector circuit shall consist of any suitable detector of sufficient sensitivity to indicate an unbalance of 0.1 ohm in the *AD* bridge arm. A heterodyne type used with a telephone receiver will be found satisfactory.

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[1] For general features of such a transformer, see "A Shielded Bridge for Inductive Impedance Measurements at Speech and Carrier Frequencies," by W. J. Shackelton, *Journal*, Am. Inst. Electrical Engrs., February, 1927, p. 159.

METHOD

Operation. 19. Suitable leads for connecting to the specimen shall be connected to terminals *C* and *D* of the bridge, Fig. 7, but not to the specimen. The bridge shall then be balanced by adjusting the differential air capacitor and the adjustable arm resistor *AD*. The capacitance and resistance values are then recorded as C_o and R_o. These readings shall be taken to compensate for the capacitance in the bridge and lead wires. The specimen shall then be connected to the lead wires, and the bridge balanced again. The capacitance and resistance values are recorded as C_1 and R_1. The equivalent parallel capacitance of the specimen is: $C_p = C_1 - C_o$, and the conductance

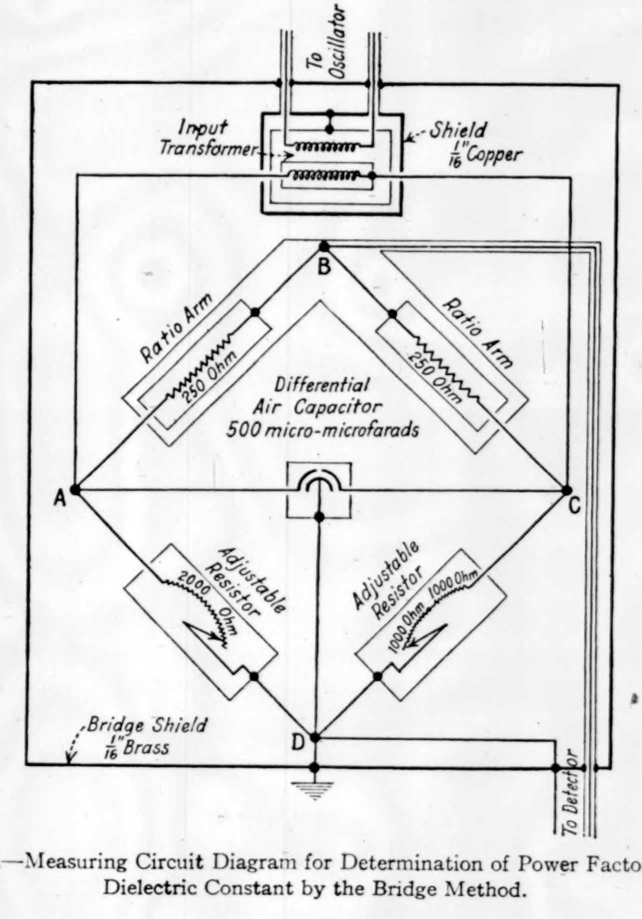
To Oscillator
Input Transformer
Shield
1/16" Copper
B
Ratio Arm
250 Ohm
Ratio Arm
250 Ohm
Differential
Air Capacitor
500 micro-microfarads
A
C
Adjustable Resistor
2000 Ohm
Adjustable Resistor
1000 Ohm
1000 Ohm
Bridge Shield
1/16" Brass
D
To Detector

FIG. 7.—Measuring Circuit Diagram for Determination of Power Factor and Dielectric Constant by the Bridge Method.

$G = \dfrac{R_o - R_l}{R_o \times R_l}$. By properly adjusting the value of R_o, G can be made substantially equal to $R_o - R_l$ times some power of ten.

The frequency shall be determined when the bridge is finally balanced.

Calculations. 20. Calculations for power factor shall be made as described in Section 5 (*b*). Calculations for dielectric constant and loss factor shall be made as described in Sections 6 and 7, respectively.

ACCURACY

Accuracy. 21. The accuracy of the power factor and dielectric constant determinations by the above methods depend critically upon the care exercised in setting up the measuring equipment and in its subsequent manipulation. The technique exercised in these respects shall be such that an accuracy within ±10 per cent for the determination of power factor, and within ±5 per cent for the determination of dielectric constant shall be obtained.

REPORT

Report. 22. The report shall include the following:

(*a*) The percentage power factor, the dielectric constant, and the loss factor of each specimen.

(*b*) The following values for the specimen: the capacitance of the specimen in microfarads; effective area of the specimen; and the average thickness of the specimen between electrodes.

(*c*) The following test conditions: the frequency in kilocycles; temperature of the atmosphere in degrees Centigrade; relative humidity of the atmosphere in per cent; and the conditioning of the specimen (hours at humidity and temperature).

(*d*) A description of the material: that is, the name, grade, and color, and the name of the manufacturer.

(*e*) Method of measurement.

TENTATIVE METHODS OF TESTING UNTREATED INSULATING PAPER[1]

Serial Designation: D 202 - 27 T

This is a **Tentative Standard,** published for the purpose of eliciting criticism and suggestions, and as such is subject to annual revision.

ISSUED, 1924; REVISED, 1925, 1926, 1927.

Scope. 1. These methods apply to untreated paper which is to be used as an electrical insulator or as a constituent of a composite material used for electrical insulating purposes.

SAMPLING

Sampling. 2. (*a*) From shipments consisting of rolls, a sample of at least 1 sq. yd. in area, cut across the entire width of the roll, shall be taken from every tenth roll in the shipment. From other shipments such as sheets or pads of tape, samples of equivalent area shall be taken in such a manner as to be equally representative of the shipment. In no case shall less than three samples be taken.

NOTE.—It is recommended that several turns of paper from each roll sampled be torn off and discarded before the samples are taken.

(*b*) The tests for physical properties shall be made upon each sample.

(*c*) The tests for acidity, moisture content, size,[2] ash and for identification of fibers[2] shall be made in duplicate upon portions taken from a composite sample. This composite sample shall be made up of a sufficient number of small pieces, each of approximately 6.5 sq.cm. (1 sq. in.) in area taken in nearly equal amounts from each of the samples taken in accordance with Paragraph (*a*).

(*d*) The required number of samples shall be taken at equal intervals across the sheet, the two end samples being taken at the edges of the sheet after removing any damaged paper. When it is not possible to secure the required number of specimens in this manner in going once across the sheet, the selection across the sheet shall be repeated as many times as necessary until the required number of specimens is secured.

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[1] Criticisms of these Tentative Methods are solicited and should be directed to Mr. T. S. Taylor, Secretary of Committee D-9 on Electrical Insulating Materials, Bakelite Corporation, 230 Grove St., Bloomfield, N. J.

[2] The tests for size, identification of fibers, and folding endurance do not appear in these methods but will be included as soon as the tests are developed by the committee.

CONDITIONING SAMPLES

Conditioning. 3. Samples shall be conditioned in air maintained at a relative humidity between 60 and 65 per cent as measured with a sling psychrometer or its equivalent. The temperature of the air shall be maintained as constant as possible at some temperature between the limits of 20 and 30° C. (68 and 86° F.). The samples should remain in the conditioned air for not less than 4 hours prior to the tests and should be supported so as to allow a free circulation around each sample. The following physical tests shall be made in the conditioned air: tensile breaking strength, tearing strength, bursting strength, folding endurance,[1] air resistance, and thickness.

MOISTURE CONTENT

Apparatus. 4. A weighing bottle, evaporating dish, thermometer, constant-temperature oven, chemical balance and desiccator are necessary for the test. The weighing bottle should be of convenient size, about 65 mm. (2.56 in.) in height and 45 mm. (1.77 in.) in diameter with a wide mouth provided with a ground-glass stopper. The chemical balance should be sensitive to 0.1 mg.

Specimen. 5. The moisture content figure is used to calculate the percentage of acidity, size, and ash of the paper to the bone-dry basis. It shall be determined on 2 to 5-g. samples selected in accordance with Section 2 (*c*).

If the moisture content of the paper as received at the purchaser's works is desired or at any other stated time, it shall be made on the sample taken at the definitely stated time by cutting small pieces of approximately 6.5 sq. cm. (1 sq. in.) in area from the required number of rolls or pads of tape in accordance with Section 2 (*a*) and immediately placed into an air-tight container.

NOTE.—Since paper adjusts itself, as regards moisture content, to the humidity of the surrounding atmosphere in a very short time (2 or 3 minutes), special care must be exercised to transfer rapidly the sample from the roll or bundle to the container and from the container to the weighing bottle.

Procedure. 6. The sample before drying shall be weighed in the tared bottle with the stopper in place. The bottle shall then be placed in the oven at 100 to 105° C. (212 to 221° F.), the stopper removed and laid alongside of the bottle and the contents transferred to the drying dish. After one hour, while still in the oven, the sample shall be replaced in the weighing bottle, and the bottle stoppered and transferred to the desiccator. The stopper should be removed while the bottle cools. When the specimen and the bottle have cooled to room temperature, the stopper shall be replaced and the bottle with its contents weighed. This process shall be repeated at intervals of one hour until the difference in weight between two successive weighings is not more than 0.2 per cent of the weight of the specimen.

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[1] The tests for size, identification of fibers, and folding endurance do not appear in these methods but will be included as soon as the tests are developed by the committee.

NOTE.—The weighing bottle or sample should not be touched with the fingers during this test.

7. The moisture content shall be expressed: **Report.**

(*a*) as a percentage of the weight of the dry sample, and

(*b*) as a percentage of the weight of the undried sample.

THICKNESS

8. A micrometer of the spring actuated, dial type shall be used. **Apparatus.** The plunger shall be capable of being raised by the application of an upward pressure to it. The plunger surface shall be circular in shape and 12.7 mm. (0.50 in.) in diameter. The anvil surface shall be plane and circular in shape, the diameter of which shall be not less than 12.7 mm. (0.50 in.). It shall be centered with respect to the plunger surface.

In addition to these requirements, the instrument shall conform to the following:

(*a*) The pressure applied to the plunger necessary to move the pointer from zero toward a positive reading shall be not greater than 1135 g. (40 oz.).

(*b*) The pressure applied to the plunger necessary to just prevent movement of the pointer from zero toward a lower reading shall be not less than 455 g. (16 oz.).

(*c*) The diameter of the dial shall be approximately 15 cm. (6 in.) and shall be graduated preferably in divisions indicating a thickness of 0.0127 mm. (0.0005 in.) and in no case greater than 0.0254 mm. (0.001 in.). Graduations indicating a thickness of 0.0254 mm. (0.001 in.) shall be at least 3 mm. (0.12 in.) apart.

(*d*) Measurements made on standard steel thickness gages shall be within the following tolerances:

INTERVALS	PERMISSIBLE DEVIATION OF READING FROM ACTUAL THICKNESS OF STANDARD STEEL GAGE
0 to 0.25 mm. (0 to 0.01 in.) incl.	±0.0025 mm. (0.0001 in.)
Over 0.25 mm. to 1.02 mm. (0.01 in. to 0.04 in.) incl.	±0.0051 mm. (0.0002 in.)
Over 1.02 mm. to 3.05 mm. (0.04 in. to 0.12 in.) incl.	±0.0102 mm. (0.0004 in.)

(*e*) Convenient means shall be provided for setting the pointer to the zero position.

(*f*) The micrometer shall be tested periodically as outlined above and if it does not conform to these requirements its mechanism should be readjusted.

Specimens. 9. Specimens shall consist of the original samples obtained in accordance with Section 2 (*a*).

Methods. 10. At least five readings shall be taken at regular intervals across the entire width of each specimen. When measuring paper less than 0.05 mm. (0.002 in.) in thickness, a sufficient number of layers to give a reading on the scale of not less than 0.13 mm. (0.005 in.) shall be used.

In making measurements the plunger shall be raised to a point where its lower surface is from 0.45 to 0.55 mm. above the surface of the paper specimen lying in contact with the surface of the fixed anvil. The plunger shall be dropped from this height on the paper without retarding its speed of descent. When the thickness is read, care shall be taken not to touch the instrument.

Report. 11. The average, maximum and minimum thicknesses obtained on each specimen shall be reported.

TENSILE BREAKING STRENGTH

Apparatus. 12. (*a*) A testing machine suitably designed for testing paper shall be used. The machine shall preferably be power driven.

(*b*) The capacity of the machine shall not exceed 113 kg. (250 lb.).

(*c*) The machine shall be graduated to read 1 lb. or 1 kg. or less per scale division for testing paper breaking at 22.7 kg. (50 lb.) or over, and to 0.5 lb. or 0.5 kg. or less for testing paper breaking under 22.7 kg. (50 lb.).

Specimens. 13. From each of the samples selected in accordance with Section 2 (*a*), specimens shall be cut at least ten in the machine direction and if practicable, ten in the cross-machine direction. The specimens shall not exceed 2.54 cm. (1 in.) in width and shall be 25.4 cm. (10 in.) in length with clean-cut edges.

Procedure. 14. (*a*) The ratio of the clearance distance between jaws to the width of the specimen shall be not less than 5:1 nor more than 10:1.

(*b*) The rate of travel of the movable jaw shall be constant. It shall preferably be 30.5 cm. (12 in.) per minute, but it may be within the limits of 28 cm. (11 in.) and 33 cm. (13 in.) per minute provided it is constant.

(*c*) All readings obtained when the paper breaks at or in the jaws shall be rejected.

Report. 15. (*a*) The results of the machine-direction specimens and the cross-machine-direction specimens shall be reported separately.

(*b*) The results shall be reported in kilograms or pounds together with the width of the specimen in centimeters or inches and also the average thickness.

(*c*) The maximum, minimum, and average breaking load shall be reported for the machine-direction and the cross-machine direction.

TEARING STRENGTH

16. The testing machine shall be of the pendulum impulse type so designed as to produce a tear approximately 4.2 cm. (1.66 in.) long. The knife mounted on the machine to cut the slit for the tear shall be maintained sharp. **Apparatus.**

17. The specimens shall be taken from the original samples obtained in accordance with Section 2 (*b*) and shall be cut 6.3 cm. (2.5 in.) in width and at least 6.3 cm. (2.5 in.) in length. Enough specimens shall be cut so that at least five readings in the machine direction and five readings in the cross-direction, if possible, can be obtained for each original sample. **Specimen.**

18. Enough paper shall be torn so that the readings on the machine shall be not less than 10 nor more than 20 g., unless one paper alone yields a reading greater than 20 g., in which case only one paper shall be torn at one time. Readings obtained when a tear deviates more than 6.3 mm. (0.25 in.) from a straight line, shall be rejected. The readings obtained shall be multiplied by the instrument constant corresponding to the number of sheets torn. **Method.**

19. (*a*) The tearing strengths obtained on the machine-direction specimens and on the cross-direction specimens shall be reported separately in grams. **Report.**

(*b*) The average, the maximum, and the minimum tearing strengths shall be reported for the machine-direction specimens. If possible, similar results shall be reported for the cross-direction specimens.

BURSTING STRENGTH

20. The testing machine shall have a circular flexible diaphragm 6.44 sq. cm. (1 sq. in.) in area. The pressure chamber shall be filled with glycerin or other suitable pressure medium and shall contain no air spaces. The test specimen shall be held in position over the diaphragm in a clamp having a circular hole approximately 6.44 sq. cm. (1 sq. in.) in area so that the diaphragm will force the paper into the hole when pressure is applied under the diaphragm. The pressure exerted on the diaphragm shall be indicated on a dial, graduated to at least 0.23 kg. (0.5 lb.) for papers giving bursting strengths 18 kg. (40 lb.) or under. A dial graduated 0.45 kg. (1 lb.) may be used in testing papers which give higher bursting strengths. The machine may be either hand-operated or power-driven, the latter being preferable. **Apparatus.**

Specimen. 21. If practicable, the specimen shall be so cut from the stock as to permit ten bursting tests on a line across the sheet or roll.

Procedure. 22. Ten bursts shall be made. The testing machine shall be driven at a uniform speed of 120 r.p.m. until the specimen bursts.

Report. 23. The report shall include the average, the maximum, and the minimum results obtained.

ABSORPTION

(RISE OF WATER)

Apparatus. 24. A suitable container and support for specimens and scale is shown in Fig. 1.

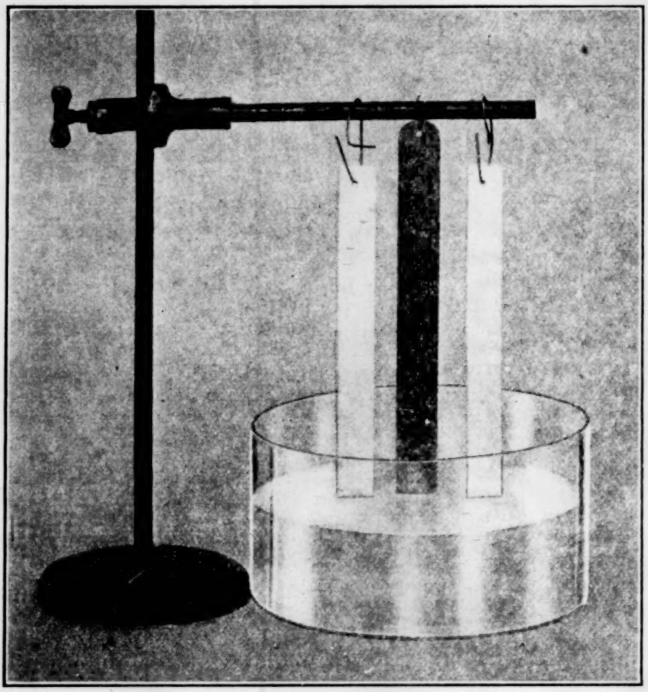

FIG. 1.—Apparatus for Absorption Test.

Specimens. 25. Ten strips 2.5 cm. (1 in.) in width and at least 12.5 cm. (5 in.) in length shall be cut from the samples obtained in accordance with Section 2 (*a*), five being cut parallel with the machine direction of the paper and five being cut parallel with the cross-direction of the paper.

Procedure. 26. The specimens shall be suspended vertically with one end dipping 3.2 mm. (0.125 in.) in distilled water at room temperature.

After five minutes of suspension, the rise of the water in the paper above the water level shall be noted. The rise may be measured by reading directly from the scale the height of absorption.

27. The rise of water shall be reported in millimeters to the nearest 3 mm. or in inches to the nearest $\frac{1}{8}$ in. **Report.**

MIL WEIGHT PER REAM

(APPARENT DENSITY)

28. A scale, sharp knife, chemical balance and weighing bottle are necessary for the test. **Apparatus.**

29. Duplicate specimens shall be taken from as widely separated portions as possible from each of the samples obtained in accordance with Section 2 (*a*) and conditioned in accordance with Section 3. **Specimens.**

30. (*a*) Each specimen while in the conditioned atmosphere (see Section 3) shall be cut accurately to any convenient size, for example, 232.3 sq. cm. (36 sq. in.) in area, and accurately weighed. Specimens of sufficient size to weigh at least from 3 to 5 g. (0.11 to 0.18 oz.) should be taken. If it is not possible to do the weighing in the conditioned atmosphere, the specimen shall be placed in a weighing bottle and tightly stoppered with a ground glass stopper before being removed from the conditioned atmosphere. The thickness of each specimen shall be determined in accordance with Section 10. **Procedure.**

(*b*) *Mil Weight per Ream of Any Size.*—The mil (or point) weight in pounds per ream of any size may be calculated from the following formula:

$$W = 0.002205 \frac{mSN}{ta}$$

where m = the weight of the specimen expressed in grams;
t = the average thickness of the specimen expressed in mils (thousandths of an inch);
a = the area of the specimen expressed in square inches;
S = the area of one sheet in the basic ream expressed in square inches;
N = the number of sheets in the ream.

NOTE.—0.002205 is contracted from 0.00220462.

NOTE.—The following formulas may be used to calculate the mil weight in pounds per ream for reams of particular sizes, provided a specimen of exactly 232.3 sq. cm. (36 sq. in.) is used:

Ream of 24 by 36 in., 480 sheets.

$$W = 25.40 \frac{m}{t}$$

where m = the weight of specimen expressed in grams:
t = the average thickness of the specimen in mils (thousandths of an inch).
25.40 is contracted from 25.3972224.

Ream of 24 by 36 in., 500 sheets.

$$W = 26.45 \frac{m}{t}$$

where m and t are the same as above and 26.45 is contracted from 26.45544.

NOTE.—The ream weight may be obtained from the above formulas by omitting the thickness "t".

(*c*) *Weight per Unit Volume.*—The weight in pounds per cubic foot (density) may be calculated from the following formula:

$$D = 3810 \frac{m}{ta}$$

where m = the weight of the specimen expressed in grams.
t = the average thickness of the specimen expressed in mils (thousandths of an inch).
a = the area of the specimen expressed in square inches.

NOTE.—3810 is contracted from 3809.58336.

NOTE.—To convert weight in pounds per cubic foot to mil weight in pounds per ream of 24 by 36 in., 480 sheets, multiply by 0.24; to convert to mil weight in pounds per ream of 24 by 36 in., 500 sheets, multiply by 0.25.

Report.

31. The weight in pounds per cubic foot or the mil weight per ream shall be reported. The size of the ream must be given when the mil weight per ream is reported.

AIR RESISTANCE

Apparatus.

32. (*a*) The instrument shall consist of two aluminum open-top cylinders, one of which is inverted and slides into the other which is fixed. The movable cylinder shall be provided with a circular aperture in the closed end and a flat ring clamp for holding the paper specimen across this aperture.

(*b*) The fixed cylinder shall be 25.4 cm. (10 in.) in height and shall have an external diameter of 8.60 cm. (3.38 in.) and an internal diameter of 8.25 cm. (3.25 in.). Four slender bars, each 18.5 cm. (7.3 in.) long, 3 mm. (0.12 in.) wide and approximately 1.5 mm. (0.06 in.) thick shall be mounted vertically and equi-distantly on the inner surface of the fixed cylinder to act as guide tracks for the movable cylinder. The movable cylinder shall be graduated in units of 50 cc. and shall have a total range of 350 cc. It shall be 25.4 cm. (10 in.) high and shall have an external diameter of 7.62 cm. (3.00 in.) and an internal diameter of 7.35 cm. (2.90 in.). It shall weigh, including the flat ring clamp and the two knurled nuts, 567 g. (20 oz.) ±5 g. (0.18 oz.). The movable cylinder and the flat ring clamp shall have a concentric circular aperture of 6.44 sq. cm. (1.00 sq. in.) in area.

When this aperture is too large for the specimen a similar movable cylinder and flat ring clamp having a concentric circular aperture of 1.61 sq. cm. (0.25 sq. in.) in area shall be used.

NOTE.—Results obtained with apertures of different areas are not directly proportional to the areas of the apertures. The proportionality factor must be determined by experiment.

Specimen.

33. The specimens shall be not less than 3.5 cm. (1.36 in.) nor more than 5.1 cm. (2.0 in.) in width cut from the original samples, taken according to Section 2 (*a*) and shall be as long as the width of the original roll of paper. If the specimens are selected from pads of tape they shall be not less than 2.1 cm. (0.81 in.) nor more than 5.1 cm. (2.0 in.) wide and at least 30 cm. (12 in.) long. There shall be as many specimens as there are original samples.

Procedure.

34. The fixed cylinder shall be placed on a rigid support so that its sides are vertical. A lubricating oil with viscosity of 60 to 70 seconds Saybolt at 37.8° C. (100° F.) shall be placed in it to a depth of 12.7 cm. (5 in.). The specimen (one thickness only) shall be secured tightly under the clamp on the movable cylinder completely covering the aperture. The movable cylinder is then floated on the ethylene glycol. The time required for the displacement of a certain amount of air is noted with a stop-watch. If possible, the amount of air displaced should be such that the time of displacement is not less than 20 seconds. The apparatus with its content of ethylene glycol shall be at the temperature of the conditioning room when the readings are taken. The time in seconds required for the displacement of 100 cc. (6.1 cu. in.) through a circular area (one side only) of 6.44 sq. cm. (1 sq. in.) of the paper is known as the air resistance of the paper.

NOTE.—The clamp shall be tested for leakage by substituting a piece of tin foil 0.05 mm. (0.002 in.) in thickness for the paper and testing in the manner described above. When so tested, the leakage shall not exceed the rate of 50 cc. in five hours

The proper procedure for clamping the specimen or tinfoil is to turn both knurled nuts down onto the clamp simultaneously. If only one nut at a time is turned down, the clamp will not fit flat on the specimen and will consequently have an avoidable leak.

Oil is used in preference to distilled water because it does not corrode aluminum whereas distilled water does.

Precautions should be taken to avoid subjecting the apparatus to vibration as this condition would increase the rate of air displacement.

Report.

35. The report shall include (1) the number of seconds required for the displacement of 100 cc. (6.1 cu. in.) of air; (2) the area of paper through which the air was displaced; (3) the thickness of the paper as obtained under Section 11 and (4) the room temperature.

ASH

Apparatus. 36. A suitable crucible such as platinum, nickel or porcelain, a balance sensitive to 0.1 mg., and a desiccator are necessary for the test.

Specimen. 37. Not less than 2 g. of dry, finely-divided paper from the "moisture determination" sample as obtained in accordance with Section 6 shall be used.

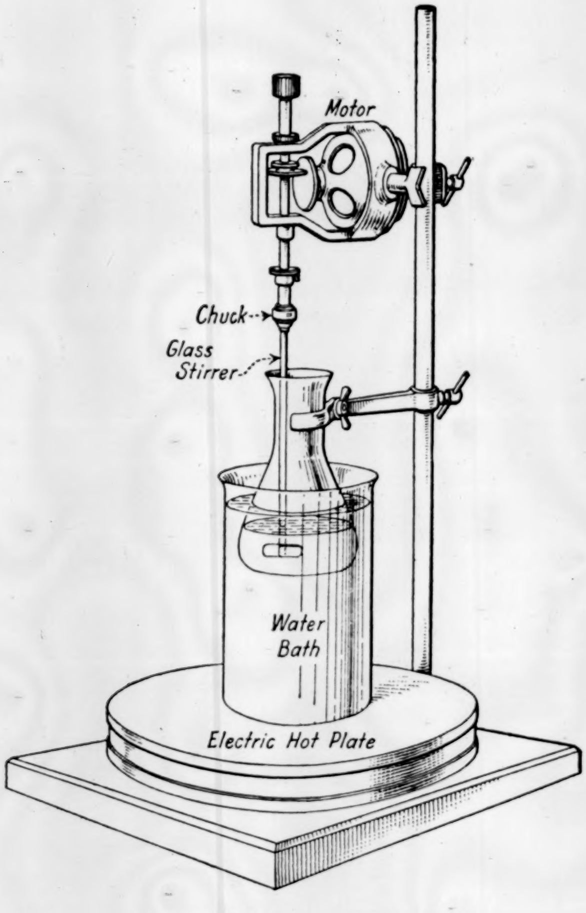

FIG. 2.—Extraction Apparatus.

Procedure. 38. The sample shall be transferred rapidly from the weighing bottle containing the dried sample into the crucible. The weighing bottle shall immediately be re-stoppered and re-weighed, and the exact weight of the sample obtained by taking the difference in weights of the weighing bottle and the sample. The sample shall be completely ignited in the crucible, preferably in a muffle furnace, all precautions being taken to prevent loss of ash or sample. The residue of incombustible mineral matter (ash) shall be desiccated, cooled and weighed, and the amount computed as a percentage of the weight of the dried sample.

Report. 39. The amount of ash shall be reported as a percentage of the weight of the dry sample (see Section 7 (*a*)) and also as a percentage of the weight of the undried sample (see Section 7 (*b*)).

ACIDITY OR ALKALINITY

Apparatus 40. (*a*) A hot water bath, electric hot plate, motor with stirrer, 50-cc. glass burette graduated to 0.1 cc., 250-cc. wide-mouth Erlenmeyer flasks, thermometer graduated to 1° C., covering the range from 50 to 100° C., and a filtering apparatus, are required for the test.

(*b*) The Erlenmeyer flasks and the stirrer shall be of acid- and alkali-resistant glass. The stirrer shall consist of a glass shaft, one end of which shall be fitted to a chuck attached to the motor shaft (see Fig. 2). The other end of the stirrer shall be fashioned into a two-bladed propeller, each blade to be approximately 15 mm. (0.59 in.) long and 6 mm. (0.24 in.) wide. The pitch of the blades and the direction of rotation shall be such as to produce a downward current along the glass shaft when the stirrer is rotated in the liquid, thus preventing spattering.

(*c*) The following reagents shall be required: Solutions of sodium hydroxide (NaOH) and sulfuric acid (H_2SO_4) in water, each being 0.01 *N* in strength; solution of 0.5 g. of phenolphthalein dissolved in 100 cc. of c. p. ethyl alcohol.

Sample. 41. (*a*) From the original samples obtained according to Section 2 (*a*), a composite sample of at least 5 g. (0.175 oz.) shall be cut into small pieces, approximately 1 cm. (0.4 in.) square. The sample shall be thoroughly mixed, and during preparation contamination by handling shall be avoided.

Procedure. 42. (*a*) *Extraction.*—One gram of the composite sample shall be placed in a 250-cc. Erlenmeyer flask and 100 cc. of boiling, distilled water added. The flask shall then be clamped in position in a water bath[1] heated to 100° C. on a hot plate. The level of the water in the bath shall be slightly above the level of that in the flask, and the temperature of the contents of the flask shall remain at least as high as 95° C. during the stirring operation. The stirrer shall be mounted so that the blades are within 3 mm. (0.12 in.) of the bottom of the flask and offset from the center in order to obtain best beating action. The stirrer shall be driven at a speed of 4000 to 5000 r.p.m. for 5 minutes. At the end of this period the sample should have been thoroughly pulped. For papers unusually difficult to pulp, the period of stirring shall be increased to 10 minutes.[1]

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[1] At high altitudes a salt bath will be necessary to obtain the temperature required.

NOTE.—It has been definitely determined that 3000 r.p.m. is too low to pulp the sample effectively within 5 minutes.

(*b*) *Titration.*—Immediately after the sample has been pulped, the contents of the flask shall be filtered rapidly into another 250-cc. Erlenmeyer flask without washing.

NOTE.—It is important that the filtration of the extract be accomplished as promptly as possible after disintegration to prevent re-absorption of acidic or alkaline material from the extract by the pulp as the temperature falls. A convenient method consists of a 25-cc. porcelain Gooch crucible and holder assembly, like that shown in Fig. 3. The pulp forms a filter mat of itself over the perforations in the bottom of the crucible and the first portion of the filtrate is re-filtered to catch the fibers which go through during the formation of the mat.

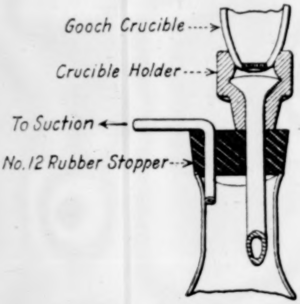

FIG. 3.—Filtration Apparatus.

The filtered extract shall be boiled for 3 minutes and immediately titrated before the temperature falls below 80° C., thus eliminating the error due to dissolved carbon dioxide.

If the extract is acidic, it is titrated with $0.01N$ NaOH, using 5 drops of the specified phenolphthalein solution as indicator. The end-point is determined by the appearance of a definite pink color. If the extract is alkaline, a small excess of $0.01N$ H_2SO_4 is added and the titration then completed with $0.01N$ NaOH as described above.

NOTE.—To find the proper color transformation at the end-point, a blank titration should be made on boiling distilled water under the above specified conditions. The result should check with the curve shown in Fig. 4. This curve will be found valuable as a check on the purity of the distilled water used, although its chief purpose is to indicate the proper blank correction to be applied to the titration.

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[1] Any other method of pulping the sample as rapidly and thoroughly, while maintaining a temperature of 95° C. within the flask during extraction, should prove satisfactory.

The number of cubic centimeters of titer solution shall be recorded, together with the temperature and volume of the solution taken immediately upon the completion of the titration, as these figures enter into the blank correction for the volume error (E_v).

43. (*a*) *Blank Correction.*—The correction for the blank error in the titration shall be made in either of two ways: **Report.**

(1) By running a blank in parallel with the actual determination using a volume of pure distilled water equal to that of the extract at the end-point;

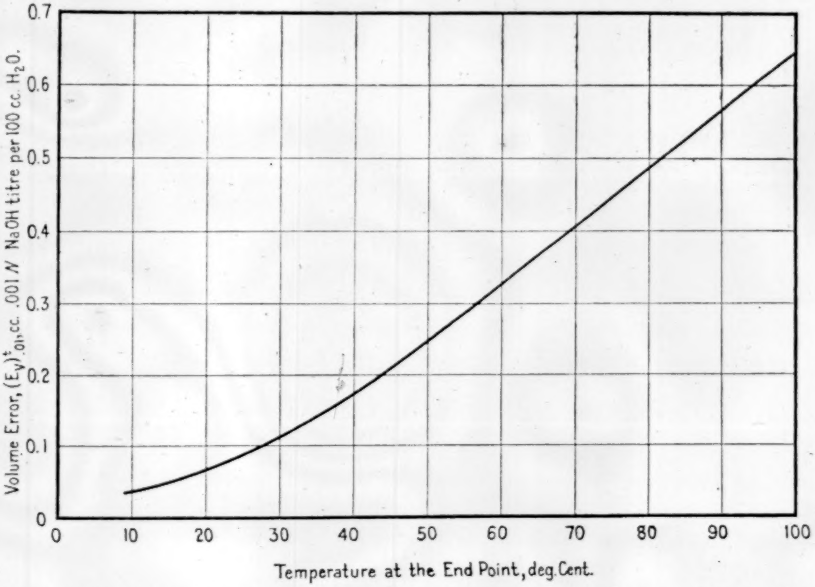

FIG. 4.—Showing Titration Error Due to Volume and Temperature of Water in a Solution at its End-Point.

If $(E_{\mathrm{v}})\frac{t}{N}$ represents the volume error of a solution where t and V are the temperature and volume at the end-point of a titration, and $N =$ the normality of the titer, then it is calculated as follows:

$$(E_{\mathrm{v}})\frac{t}{N} = (E_{\mathrm{v}})^{t}.01 \times \frac{.01}{N} \times \frac{V}{100}$$

(2) By calculating the blank error with the aid of the curve shown in Fig. 4.

NOTE.—The second method is the more convenient and probably more reliable. This curve shows the number of cubic centimeters of $0.01N$ NaOH solution required to produce an end-point at various temperatures in 100 cc. of distilled water, using 5 drops of the specified indicator. Correction by the use of this curve is valid only if the solution has been boiled and titrated at elevated temperatures to insure absence of dissolved CO_2.

This correction is the number of cubic centimeters of titer solution (volume error) corresponding to the point on the curve determined by the temperature and volume of the solution at the end-point. If the solution is acidic, this blank correction shall be subtracted from the volume of titer used; if alkaline the correction shall be added.

(*b*) *Calculation.*—The acidity or alkalinity shall be calculated from the following equation:

$$\text{Per cent acidity (or alkalinity)} = \left\{ \begin{matrix} \text{cubic centimeter} \\ \text{titer solution (corrected)} \end{matrix} \right\} \times \frac{\text{normality}}{1000} \times 40 \times 100$$

A simpler form is:

$$\text{Per cent acidity (or alkalinity)} = \left\{ \begin{matrix} \text{cubic centimeter} \\ \text{titer (corrected)} \end{matrix} \right\} \times \text{normality} \times 4.$$

(*c*) *Expression of Results.*—The results shall be expressed as the equivalent weight per cent of NaOH if the extract is acidic, or as equivalent weight per cent of SO_3 if the extract is alkaline; this percentage being based on the weight of the air-dry sample in grams.

NOTE.—SO_3 is used rather than H_2SO_4 in this calculation as the equivalent weight of SO_3 is identical with that of NaOH, and this makes it possible to express acidity or alkalinity in directly comparable terms.

(*d*) *Number of Tests.*—At least two samples shall be carried through the foregoing procedure. If in duplicate samples the values of percentage acidity or alkalinity do not agree within 0.005, the determinations shall be repeated.

NOTE.—There is given in an appendix to the report of Committee D-9 for 1926, information regarding the details of the foregoing method, and reasons are presented for the selection of the conditions specified.

SURVEY FOR CONDUCTING PATHS

Scope. 44. The survey for conducting paths in untreated insulating paper is a test to determine the number of conducting paths in the paper as indicated by the number of electrical breakdowns (or points of excessive current flow in thin papers (see Section 45 (*b*)) when relatively large areas of the paper are subjected to a voltage somewhat lower in value than the dielectric strength of the paper when tested in accordance with Sections 2 to 12 of the Tentative Methods of Testing Sheet and Tape Insulating Materials for Dielectric Strength (Serial Designation: D 149 – 27 T) of the American Society for Testing Materials.[1]

Apparatus. 45. (*a*) The survey shall be made by passing a specimen of the paper between metallic electrodes across which a voltage is impressed. The arrangement of the apparatus may be of any convenient form which will allow the application of the required voltage to a specimen of relatively large area, and will allow the electrical breakdowns to be indicated so that the number of these may be counted.

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[1] See p. 995.

(*b*) For papers having a thickness of 0.038 mm. (0.0015 in.) or less it has been found preferable to use a detecting device such as a telephone receiver to detect the excessive current through the conducting paths rather than to allow complete electrical breakdown of the specimen. Also, it is preferable to pass one electrode over the paper rather than to draw the paper through between the electrodes.

Specimens.

46. The specimen shall be of relatively large area, such as a pad of tape, or a sheet from each sample of paper (see Section 2 (*a*)). For sheet material such as pressboard either the entire sheet or a relatively large portion of a sheet shall be used. The specimen shall be representative of the shipment. (Section 2 (*a*)).

Procedure.

47. The survey shall be made by passing the specimen between the metallic electrodes at a speed of 30 to 60 ft. per minute. The voltage impressed across the electrodes shall be 100 volts per mil thickness of the specimen if alternating voltage is used, or 141 volts per mil thickness of the specimen if direct voltage is used.

Note 1.—If the voltage values specified above prove inconvenient of application, a lower voltage may be used, in which case it is necessary to establish a relationship between the conducting paths at this voltage and at the specified voltage. A lower value of conducting paths will be obtained at the lower voltage.

Note 2.—A description of equipment and a procedure which have been found suitable for making this survey of conducting paths in different thicknesses of paper may be had upon application to the secretary of Committee D-9.

Report.

48. The report shall include the following:

(*a*) The total number of conducting paths and the conducting paths per unit area.

(*b*) The length, width, area, and thickness of the specimen.

(*c*) The voltage applied expressed in volts, and volts per mil thickness of specimen.

(*d*) The speed of the paper.

TENTATIVE SPECIFICATIONS
FOR
RUBBER INSULATING TAPE.[1]

Serial Designation: D 119 – 27 T.

This is a **Tentative Standard,** published for the purpose of eliciting criticism and suggestions, and as such is subject to annual revision.

ISSUED, 1921; REVISED, 1922, 1927.

Material Covered.

1. These specifications cover rubber insulating tape to be used for insulating joints in electric wires and cables.

MANUFACTURE

Compound.

2. The tape shall be made from an unvulcanized rubber compound which shall be well, evenly and smoothly calendered, cut to uniform width and tightly wound in rolls with a glazed cloth, parchment paper or a linen separator interposed between adjacent layers.

Separator.

3. The separator shall be attached to and cover the outer side of the tape. When unwound from the original roll, it shall show no undue tendency to stick to the rubber.

CHEMICAL PROPERTIES AND TESTS

Composition.

4. The tape shall be a rubber compound containing not less than 30 per cent of the best quality Hevea rubber, not more than one per cent of free sulfur and not more than 4 per cent of waxy hydrocarbons.

The remainder shall consist only of suitable dry inorganic mineral fillers. The compound shall contain no reclaimed rubber, substitutes or organic matter other than herein above specified. All percentages shall be based on the weight of the original compound.

Chemical Analysis.

5. If an analysis of the compound is made, it shall be carried out in accordance with Sections 15 to 47, inclusive (Joint Rubber Insulation Committee's Procedure), of the Standard Methods of Testing Rubber

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[1] **Criticisms of these Tentative Specifications are solicited and should be directed to Mr. E. H. Grafton, Secretary of Committee D-11 on Rubber Products,** Murray Rubber Co., Trenton, N. J.

Products (Serial Sesignation: D 15) of the American Society for Testing Materials[1], with the following exceptions:

(*a*) Omit "chloroform extract" from the diagram in Fig. 2 and from the tabulation in Section 45.

(*b*) In place of Section 20 substitute the following: "Remove the rubber compound from the separator and cut into as thin strips as possible."

(*c*) Omit Sections 25 and 33.

(*d*) In Section 34, substitute "acetone" for "chloroform" in the first and second lines.

(*e*) In Section 38, omit "from the conductor" in the third and fourth lines.

(*f*) In Section 46, omit "and chloroform" and substitute "extract" for "extracts" in the first sentence. Omit the second sentence.

(*g*) In Section 47, omit "chloroform extract."

PHYSICAL PROPERTIES AND TESTS

Tensile Strength.

6. (*a*) The tensile strength of the tape shall be not less than 250 lb. per sq. in.

(*b*) The tests shall preferably be made with a power driven, pendulum-type tension testing machine; the initial distance between the jaws shall be 3 in. and the rate of separation of the jaws shall be 20 in. per minute. The width of the test specimen shall be 0.5 in.

(*c*) Three specimens of each sample free from visible flaws shall be tested. The average result shall be taken as the tensile strength.

(*d*) The temperature of the room shall be not lower than 65° F. (18° C.) nor higher than 90° F. (32° C.) and the samples shall have been kept within these temperature limits for at least 30 minutes previous to the time of testing.

Dielectric Strength.

7. Two brass-ball sphere electrodes 2 cm. in diameter shall be brought so close together that the sample of tape can be just moved between them. The tape shall withstand without puncturing the application of a potential of 10,000 volts (r.m.s. value) for a period of five minutes applied to the sphere electrodes at a frequency not exceeding 65 cycles per second.

Fusion.

8. The tape shall be tested for fusion as follows:

(*a*) The sample shall have been kept at a room temperature of not less than 65° F. (18° C.) nor more than 90° F. (32° C.) for at least 30 minutes previous to making the test.

(*b*) The sample shall be tested on a mandrel $\frac{1}{4}$ in. in diameter which shall be mounted in a level position in ball bearings of the Fafnir

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[1] 1927 Book of A.S.T.M. Standards, Part II.

Bearing Co., Catalog No. 0.096 or equivalent ball bearings. The mandrel shall turn freely under a weight of 5 g. suspended from a cotton thread wound in a single layer on the center of the mandrel.

(*c*) A sample 7 in. long shall be taken from the roll, care being taken not to touch the surface to be tested with the hands or otherwise, and 2 in. of the sample shall be wound on the mandrel, and then a weight of 4 lb. per inch of width of the tape shall be attached and the tape wound on the mandrel for 3 in. at the uniform rate of approximately 15 r.p.m. The tape shall stand for 3 minutes with the weight attached and then allowed to unwind at the same rate until the fused turns are reached. The tape shall then sustain the weight for 2 minutes without further unwinding or shall break at the point of unwinding.

Test Samples.

9. One roll for each 250 rolls shall be taken at random for test. At least 2 ft. of the outer layers shall be removed and discarded before taking specimens for test.

STANDARD WEIGHTS, DIMENSIONS AND VARIATIONS

Thickness, Weight and Yardage.

10. The tape shall conform to the following requirements:

WIDTH, IN.	THICKNESS, IN.	NOMINAL WEIGHT PER ROLL, LB.	MINIMUM NET WEIGHT PER 100 ROLLS, LB.[a]	MINIMUM LENGTH PER POUND, YD.[b]
½	0.030	½	50	26¼
¾	0.030	½	50	17½
1	0.030	1	100	13

[a] Exclusive of core, wrapping and box.

[b] Exclusive of core, wrapping, box and separator.

Permissible Variations.

11. The width shall not vary from the specified value by more than $\frac{1}{32}$ in. The thickness shall not vary from the specified value by more than 0.003 in.

Measurement of Thickness.

12. The thickness shall be measured with a micrometer graduated to 0.001 in. having a circular foot, 0.24 to 0.26 in. in diameter, and with a pressure on the specimen of not less than 8 oz. or more than 10 oz. Four measurements shall be made at random in a length of not less than 3 ft. and no measurement shall be outside the limits prescribed in Sections 10 and 11.

PACKING AND MARKING

Packing.

13. Each roll shall be wrapped in paraffined paper or metal foil and enclosed in a suitable box. The wrapping shall be secure and shall thoroughly protect the contents.

Marking.

14. Each box shall be marked with the name of the manufacturer or trade mark and the nominal width and weight of the tape.

INSPECTION AND REJECTION

Time of Inspection.

15. The tape shall be tested and inspected within four weeks of the date of delivery.

Retest and Rejection.

16. If the tape fails in any one test of those prescribed in these specifications, two additional specimens shall be taken and submitted to that test. If either of these two additional specimens fails, the lot of tape represented by that sample roll shall be rejected.

TENTATIVE SPECIFICATIONS
FOR
TOLERANCES AND TEST METHODS FOR RAYON[1]

Serial Designation: D 258 - 27 T

This is a **Tentative Standard,** published for the purpose of eliciting criticism and suggestions, and as such is subject to annual revision.

ISSUED, 1926; REVISED, 1927.

DEFINITIONS

1. (*a*) *Rayon* (formerly known as artificial silk).—A generic term for filaments made from various solutions of modified cellulose by pressing or drawing the cellulose solution through an orifice, and solidifying it in the form of a filament, or filaments, by means of some precipitating medium.

(*b*) *Rayon Yarns.*—Yarn composed of more than one continuous rayon filament.

(*c*) *Spun Rayon.*—Yarn made from cut rayon filaments, the cut filaments being twisted and drawn out into a yarn by usual spinning processes.

Classification. 2. (*a*) *Nitro-Cellulose Rayon* (Chardonnet).—Filaments composed of a regenerated or denitrated cellulose which has been coagulated or solidified from a solution of nitrated cellulose.

(*b*) *Viscose Rayon.*—Filaments composed of a regenerated cellulose which has been coagulated or solidified from a solution of cellulose zanthate.

(*c*) *Cuprammonium Rayon.*—Filaments composed of a regenerated cellulose which has been coagulated or solidified from a solution of cellulose in ammoniacal copper oxide.

(*d*) *Cellulose-Acetate Rayon.*—Filaments composed of an acetic ester of cellulose which has been coagulated or solidified from its solution.

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[1] Criticisms of these Tentative Specifications are solicited and should be directed to Mr. K. B. Cook, Secretary of Committee D-13 on Textile Materials, Winnsboro Mills, Winnsboro, S. C.

IDENTIFICATION

3. Any rayon tested by these methods shall be in the bleached or unbleached state and shall be free from oil or other foreign substances.

TO DISTINGUISH CELLULOSE-ACETATE FROM ALL OTHER RAYONS

4. The fibers shall be twisted to a tight wad and cautiously approached to a match flame.

(*a*) Cellulose-acetate rayons "melt" or "fuse" and burn more slowly than other rayons, and harden at once into a brittle substance, globular in appearance.

(*b*) Viscose, nitro-cellulose and cuprammonium rayons all burn like cotton, that is, with no odor and leaving very little ash.

5. Cellulose-acetate is readily soluble in pure acetone in concentrations of not over 1 per cent. This serves as a confirmatory means of differentiating cellulose-acetate rayons from other rayons which are not soluble in this solution.

TO DISTINGUISH NITRO-CELLULOSE RAYON FROM VISCOSE AND CUPRAMMONIUM RAYONS

6. The yarn shall be moistened with a solution consisting of 1 per cent of diphenylamine in concentrated sulfuric acid (sp. gr. 1.84).

(*a*) Nitro-cellulose rayons assume immediately a deep blue color. The fibers dissolve rapidly to a blue solution.

(*b*) Viscose and cuprammonium rayons are not colored blue and dissolve more slowly.

TO DISTINGUISH CUPRAMMONIUM RAYON FROM VISCOSE RAYON

7. The yarn shall be immersed for one minute in a boiling solution consisting of 1 per cent of silver nitrate, 4 per cent of sodium thiosulfate and 4 per cent of sodium hydroxide.

(*a*) Cuprammonium rayon will remain unstained.

(*b*) Viscose rayon will be stained a brown or reddish brown color. This reaction will also produce a brown stain on nitrocellulose rayon.

NOTE.—*Preparation of Test Solution.*—Dissolve the silver nitrate and sodium thiosulfate separately. Add the first to the second and the cloudiness will disappear. Add the previously dissolved sodium hydroxide. Make up to correct volume, bring to a boil, and filter.

TOLERANCES

SIZE OR YARN NUMBER (DENIER)

8. The denier of a yarn is the weight in grams of 9000 meters.

Size of Rayon Yarn.

9. (*a*) The average size or denier of each skein, tube, spool, cop, pirn or cone of rayon as supplied by the seller either bleached or unbleached, as found by test, shall not vary above or below the specified size or denier more than:

10 per cent for sizes finer than 150 denier, and
8 per cent for 150 denier or coarser.

(*b*) The average size or denier of each case of skeins, tubes, spools, cops, pirns, cones, or a beam warp of rayon yarn in the singles, either bleached or unbleached, as found by test shall not vary above or below the specified size more than:

5 per cent for sizes finer than 150 denier, and
4 per cent for 150 denier or coarser.

Size of Spun Rayon Yarn.

10. The average size or denier of each case of skeins, tubes, spools, cops, pirns, cones, or a beam warp of spun rayon yarn in the singles, either bleached or unbleached, as found by test, shall not vary more than 5 per cent above or below the specified size.

TWIST AND DIRECTION OF TWIST

Definition.

11. *Direction of Twist.*—The yarn has right-hand or regular twist if, when it is held vertically, the spirals or twists are seen to incline upward in a right-hand direction, and has left-hand or reverse twist when the spirals or twists are seen to incline upward in a left-hand direction.

12. The average twist of each case of skeins, tubes, spools, cops, pirns, cones, or a beam warp of yarn shall not vary beyond the following specified limits:

TURNS PER INCH	ALLOWABLE VARIATIONS
Under 7½	±25 per cent
7½ to 10	±15 per cent
Over 10	± 5 per cent

STRENGTH

13. (*a*) The average tensile strength of each case of skeins, tubes, spools, cops, pirns, cones, or a beam warp of yarn in the singles, or plied, either bleached or unbleached, as found by test, shall not be less than the specified strength.

(*b*) Ultimate strength, or strength at the highest yield point, may be specified.

TEST METHODS

SIZE OR YARN NUMBER (DENIER)

(*A*) *Preferred Method*

14. The number or denier shall be determined (except when the rayon is on beams) from skeins which have been prepared, reeled and weighed in an atmosphere, kept in rapid motion by an electric fan, of 65 per cent relative humidity and 70° F. (21° C.) after the spools, cops, tubes, cones, skeins, or other packages from which the test skeins are to be reeled have been conditioned in this atmosphere for three hours when in skeins, and twelve hours when in any of the other forms.

15. Any reel having a perimeter of 112.5 cm. may be used. (See note.) For yarns in skein form, a speed of 100 to 150 r. p. m. shall be used. For yarns on spools, cops, tubes or cones, the yarn shall be drawn off over end and a speed of 200 to 300 r. p. m. of the reel shall be used. The tension on the yarn shall not be heavier than is necessary to lay the yarn smoothly on the reel at the specified speed. The skeins shall be weighed separately on a balance which shall be accurate to 0.25 per cent of the average weight of one skein.

16. Two skeins of 200 turns each from each of 10 spools, cops, tubes, cones or skeins, from one case out of every 10 cases shall be made, and the average of these 20 tests shall be the size or denier.

17. Rayon received on beams shall be tested as specified.

18. The size or yarn number in denier is calculated as follows:

$$\text{Size or yarn number} = \text{Weight of 225-meter skein in grams} \times 40$$

19. The yardage per pound of rayon of any given denier may be calculated by the following formula:

$$\text{Yards per pound of rayon} = \frac{4{,}464{,}528}{\text{Given denier}} \text{ (yards per pound of one denier yarn)}$$

(*B*) *Alternate Method*

20. The winding and weighing of the skeins shall be carried out under prevailing atmospheric conditions, following in all other respects the procedure outlined in Sections 14 to 19. The results thus obtained shall be reduced to a common basis of standard moisture regain for the class rayon under test by the following formulas:

(*a*) For nitro-cellulose, viscose and cuprammonium rayons.—

$$\text{Denier corrected to 14.5-per-cent moisture regain} = \frac{\text{Denier} \times 114.5}{(100 + \text{actual percentage of regain})}$$

(*b*) For cellulose-acetate rayons.—

$$\text{Denier corrected to 6.5-per-cent moisture regain} = \frac{\text{Denier} \times 106.5}{(100 + \text{actual percentage of regain})}$$

21. To determine the actual percentage of moisture regain present in the sizing skeins, two groups of three skeins each shall be taken immediately after weighing and the weight of each group recorded. They shall then be placed in two separate baskets in a conditioning oven and dried to constant weight on a balance sensitive to 0.25 per cent of the average weight of one skein at 105 to 110° C. (221 to 230° F.). The moisture regain of each group shall then be computed as the percentage of the dry weight and the average of these two shall be the actual percentage of moisture regain in the sizing skeins.

NOTE.—In a laboratory which is equipped for testing cotton yarns only, the skeins may be prepared on any reel having a perimeter of 1½ yards. Each skein must contain 200 ends as before.

If a skein of this length is used the yarn number or denier must be calculated by means of the following formulas:

If the weighing is made in grams.—

$$\text{Yarn number or denier} = \frac{\text{Weight of 300-yd. skein in grams} \times 1.64}{0.05 \text{ gram (per denier)}}$$

If the skeins are weighed in grains.—

$$\text{Yarn number or deneir} = \frac{\text{Weight of 300-yd. skein in grains} \times 1.64}{0.7716 \text{ grain (per denier)}}$$

STRENGTH

(*A*) *Preferred Method*

22. One skein from each of the ten spools, cops, tubes, cones or skeins drawn for a sample shall be prepared as described in Sections 15 and 16. The number of turns in these strength skeins shall be as specified in Table I. For sizes which require 200 ends, ten of the sizing skeins may be used if desired.

TABLE I

DENIER OF RAYON	NO. OF TURNS IN STRENGTH SKEIN
1 - 50 denier	400
51 - 75 "	200
76 - 120 "	150
121 - 200 "	100
Over 200 "	50

23. After conditioning for at least three hours in an atmosphere, kept in rapid motion by an electric fan, of 65 per cent relative humidity and 70° F. (21° C.) these ten skeins shall be separately broken on an

automatic power yarn tester of inclination balanced type of 25 kg. (55 lb.) or 50 kg. (110 lb.) capacities. The lower capacity shall be used until the swing of the pendulum exceeds an angle of 45 deg. from the vertical. When yarns break above this mark the higher capacity of testing machine shall be used.

24. The machine shall be equipped with an automatic charting device to record stretch at any load.

25. Any tendency to friction, backlash, or play in the recording device, lower jaw, or screw, shall be overcome as far as practicable by counter balancing.

Jaws. 26. Clamps for holding the 200-end test skein shall consist of flat metallic jaws. These shall be covered with one layer of rubber tire tape which shall press directly against the specimen. One gripping surface shall be hinged or swiveled and the other shall be rigidly connected to the frame of the jaw. The pressure between the jaws shall be secured by any suitable mechanical device so constructed as to grip the yarns firmly before the testing load is applied and prevent visible slipping during the progress of the test.

27. The initial distance between jaws shall be 10 cm. (4 in.). The skein to be tested shall first be clamped in the upper jaws, spread out evenly so that the ends are parallel, forming a ribbon approximately $\frac{3}{8}$ to $\frac{3}{4}$ in. in width. The rayon shall then be drawn down through the lower jaws and spread out to make a band of equal width, pulled just taut and clamped.

Speed of Jaw. 28. The pulling jaw shall travel at a speed of 6 in. per minute. One test shall be made on each of the 10 skeins prepared as in Section 22 and the average of these 10 tests shall be the strength.

(*B*) *Alternate Method*

29. Five single strands from each of 10 spools, cops, tubes, cones, or skeins, shall be broken after conditioning the skeins for three hours and any other form of package for 12 hours in an atmosphere, kept in rapid motion by an electric fan, of 65 per cent relative humidity and 70° F. (21° C.). A single strand tester of proper capacity with the jaws set 10 in. between grips and having a speed of pulling jaw of 12 in. per minute shall be used.

30. The average of 50 tests shall be the tensile strength.

TWIST

31. The twist shall be determined on any standard twist tester with jaws set 10 in apart. The yarn shall be clamped in the jaws under a definite tension by attaching weights. The tension to be

used shall approximate a value to be determined by the following formula:

$$\text{Tension in grams} = \frac{\text{Specified denier}}{30}$$

Example.—The weight for 150 denier rayon would be $\frac{150}{30} = 5$ g.

32. Two tests, from each of five spools, cops, tubes, cones or skeins, shall be made and the average of these ten tests calculated to turns per inch shall be the twist.

MOISTURE REGAIN

33. The standard moisture regain of nitro-cellulose, viscose and cuprammonium rayons shall be 14.5 per cent of the dry weight.

34. The standard moisture regain of cellulose-acetate rayons shall be 6.5 per cent of the dry weight.

TENTATIVE SPECIFICATIONS

FOR

TOLERANCES AND TEST METHODS FOR CERTAIN LIGHT AND MEDIUM COTTON FABRICS[1]

Serial Designation: D 274 – 27 T

This is a **Tentative Standard,** published for the purpose of eliciting criticism and suggestions, and as such is subject to annual revision.

ISSUED, 1927.

Tolerances. 1. Tolerances shall be the limits within which the fabric must come in its specified characteristics in order that it shall constitute a good delivery on contract (Note 1).

Standard Methods. 2. All test procedures not otherwise specified shall be in accordance with the Standard General Methods of Testing Woven Textile Fabrics (Serial Designation: D 39) of the American Society for Testing Materials.[2]

Classification. 3. Light and medium fabrics shall be assigned to one of the following classes and shall be subject to the requirements for tolerances specified for that class.

Class A.—Airplane wing fabric, balloon cloth, osnaburg and other fabrics covered by specifications.

Class B.—Print cloth, sheeting, pillow tubing, carded lawn, pajama checks, and bunting.

Class C.—Denims, drill, twill, cotton flannel, and buckram.

Class D.—Blanket cloths.

WIDTH

4. (*a*) The width shall be measured between the selvages to an accuracy of $\frac{1}{16}$ in.

(*b*) The average width shall be as specified with a tolerance of plus 2 per cent or minus 1 per cent in the case of Class B fabrics and plus or minus 2 per cent in the case of Class C and Class D fabrics.

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[1] Criticisms of these Tentative Specifications are solicited and should be directed to Mr. K. B. Cook, Secretary of Committee D-13 on Textile Materials, Winnsboro Mills, Winnsboro, S. C.

[2] 1927 Book of A.S.T.M. Standards, Part II.

WEIGHT

5. The weight, when determined in accordance with the Standard Methods D 39, shall be as specified with a tolerance of plus or minus 2.5 per cent in the case of Class B, Class C and Class D fabrics.

THREADS PER INCH

6. (*a*) Unless the thread count specified is indicated as the minimum acceptable, the tolerance on thread count shall be plus or minus 4 per cent in the case of Class B fabrics and plus or minus 5 per cent in the case of Class C and Class D fabrics.

(*b*) In fabrics where there are fewer than 30 threads per inch, a 3-in. gage length shall be used in making the determination.

(*c*) When the size of the sample permits, thread counts shall be taken about 6 in. apart. No warp count shall be taken at a point less than 8 in. from the selvage.

TENSILE STRENGTH

Tensile Strength.

7. The tensile or breaking strength, when determined in accordance with the 1 by 1 by 3-in. grab method described in Standard Methods D 39, shall not be less than that specified.

TEARING STRENGTH[1]

EXPLANATORY NOTE

NOTE 1. The attention of the consumer is called to the fact that each additional specification requirement must necessarily add to the cost of production. Therefore, only essential details should be specified.

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[1] Tolerances and test procedure for tearing strength will be included as soon as the test is developed by the committee.

TENTATIVE SPECIFICATIONS AND TESTS
FOR
CUBAN (JUTE) RAW SUGAR BAGS[1]

Serial Designation: D 275 - 27 T

This is a **Tentative Standard,** published for the purpose of eliciting criticism and suggestions, and as such is subject to annual revision.

ISSUED, 1927.

Standard Methods. 1. All test procedure not covered in these specifications shall be in accordance with the Standard General Methods of Testing Woven Textile Fabrics (Serial Designation: D 39) of the American Society for Testing Materials.[2]

Tolerances. 2. Tolerances shall be the limits within which the fabric or bags must come in their specified characteristics in order that they shall constitute a good delivery on contract.

SAMPLING

Sampling. 3. One bale from each thirty bales from each mill shall be taken at random from each shipment of bags, and ten bags from different parts of the bale shall be taken for test purposes from each of these bales. In no case shall less than two bales be taken from any one shipment of a mill. These bags shall be selected and tested within two months after arrival at their final destination as shown on the bill of lading.

REQUIREMENTS AND METHODS OF TEST

A. Material (Gunny Sacking)

Weave. 4. The weave shall be a $\frac{2}{1}$ twill known as a 7 by 9 or 8 by 8 Porter and Shot.

NOTE.—Porter threads are double (warp); Shotting threads are single (filling).

Thread Count. 5. The thread count shall be either 21 or 24 single ends per 37/40 in. in the Porter, and 8 or 9 single ends per inch in the Shotting, depending on the construction specified by the purchaser.

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[1] **Criticisms of these Tentative Specifications are solicited and should be directed to Mr. K. B.** Cook, Secretary of Committee D-13 on Textile Materials, Winnsboro Mills, Winnsboro, S. C.

[2] 1927 Book of A.S.T.M. Standards, Part II.

Width. 6. The width of the material when measured at right angles to the selvage with the material smoothed out flat with sufficient tension to remove all wrinkles shall not averge less than 30 in., and in no place shall it be less than 29½ in.

Weight. 7. (*a*) The weight of the material shall average 15.0 oz. per lineal yard (18.0 oz. per sq. yd.), and at no place shall it be more than 5 per cent under the specified weight.

(*b*) The weight shall be determined under standard atmospheric conditions upon material having a normal moisture content obtained by exposure for at least 4 hours to an atmospheric condition of 65-per-cent relative humidity at a temperature of 21° C. (70°F.).

Tensile Strength. 8. (*a*) The average tensile strength of the material shall not be less than 125 lb. in the Porter and 90 lb. in the Shotting.

(*b*) The tensile strength shall be obtained on an approved type of inclination balance machine, motor driven. It shall be determined under standard atmospheric conditions upon material having a normal moisture content obtained by exposure for at least 4 hours to an atmospheric condition of 65-per-cent relative humidity at a temperature of 21° C. (70° F.). The method of test shall be that known as the "grab method."

Sizing. 9. No fish oil, sizing, or loading compound known to be injurious to the material, or that will materially affect its weight or strength shall be used.

B. Bags

Length. 10. The length of the bags shall average that specified by the purchaser and shall be measured at two places with bags folded down the center parallel to the selvage. The measurements shall be made along the fold of the bag and 3 in. from the edge. Sufficient tension shall be placed on the bags to smooth out the wrinkles.

Width. 11. The width of the bags shall average that specified by the purchaser and shall be measured at three places with the bags folded in the center at right angles to the selvage. The measurements shall be made at the center of the folded length and 3 in. from each end. Sufficient tension shall be placed on the bags to smooth out the wrinkles.

Weight. 12. (*a*) The weight of the standard bags shall be as follows:

STANDARD SIZE	WEIGHT
30 by 48 in.	41.25 oz.
30 by 50 in.	42.90 oz.

In no case shall the weight of the bag be more than 5 per cent under the specified weight. The weight of bags other than standard sizes shall be in proportion to these weights.

(*b*) The weight of the bags shall be determined under standard atmospheric conditions upon bags having a normal moisture content obtained by exposure for at least 4 hours to an atmospheric condition of 65-per-cent relative humidity at a temperature of 21° C. (70° F.).

(*c*) *Alternative Method for Weight.*—If standard atmospheric conditions are not obtainable the weight may be determined by correcting to a moisture regain of 13.0 per cent.

13. (*a*) The seams shall be $\frac{1}{2}$ in. dry-sewn with a two-thread overhead stitch with not less than 5 stitches to 2 in. **Seams.**

(*b*) The average tensile strength of the seam shall average not less than 100 lb., the test being made by the grab method.

14. The hem shall be $1\frac{1}{2}$ in. double rolled around the top of the bag. **Hem.**

15. All bags shall be woven without a colored stripe. **Stripe.**

RETESTING

16. (*a*) Should the bags fail to conform to the requirements specified, a retest shall be made before final rejection of the shipment. **Retest.**

(*b*) Bags for retest shall be taken from other bales in the manner specified in Section 3.

TENTATIVE METHODS FOR IDENTIFICATION OF TEXTILE FIBERS AND THEIR QUANTITATIVE DETERMINATION IN MIXED GOODS[1]

Serial Designation: D 276 – 27 T

This is a **Tentative Standard,** published for the purpose of eliciting criticism and suggestions, and as such is subject to annual revision.

Issued, 1927.

General Characteristics and Appearance of the Most Important Textile Fibers

Cotton:

Normal cotton fibers appear as long, colorless, twisted, ribbon-like cellular structures with thickened edges, due to the collapse of the original hollow cylindrical structure or tube. Most fibers have a flattened central air-filled canal or lumen. The length of the fibers varies with the variety from about ½ to 2 in. and the diameter or ribbon width from about 0.00063 to 0.00090 in. The number of natural twists or convolutions along the fibers varies considerably, ranging from about 159 to 225 per in. These twists occur in both directions.

Flax or Linen:

Flax fibers appear as long, pointed, cylindrical cells, colorless, and fairly uniform in structure. They usually possess a central lumen as a narrow line, which often appears to be double. Characteristic slight swellings or nodes are to be found at fairly regular intervals, with fine, almost invisible cross-lines. The nodes, discolorations, and cross-lines are more pronounced in woven fabrics than in raw flax.

Individual fibers have very variable diameters, the finest flax being finer than cotton. The fibers may be split into finer and finer sizes almost indefinitely.

Commercial flax usually runs about 20 in. in length, but individual fibers may run up to 36 in. or even longer. In woven fabrics, the yarns at times will show a characteristic abrupt change in diameter locally where fibers have been partly split off in hackling. In contrast to this, cotton yarns vary in size in a tapering manner.

Hemp (Common hemp, *Cannabis Sativa*):

Hemp fibers are composed of groups of long, blunt cells, not pointed at the ends as flax, though often of a forked shape. All show large, well defined lumens equalling or exceeding the thickness of the walls. There are usually

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[1] Criticisms of these Tentative Methods are solicited and should be directed to Mr. K. B. Cook, Secretary of Committee D-13 on Textile Materials, Winnsboro Mills, Winnsboro, S. C.

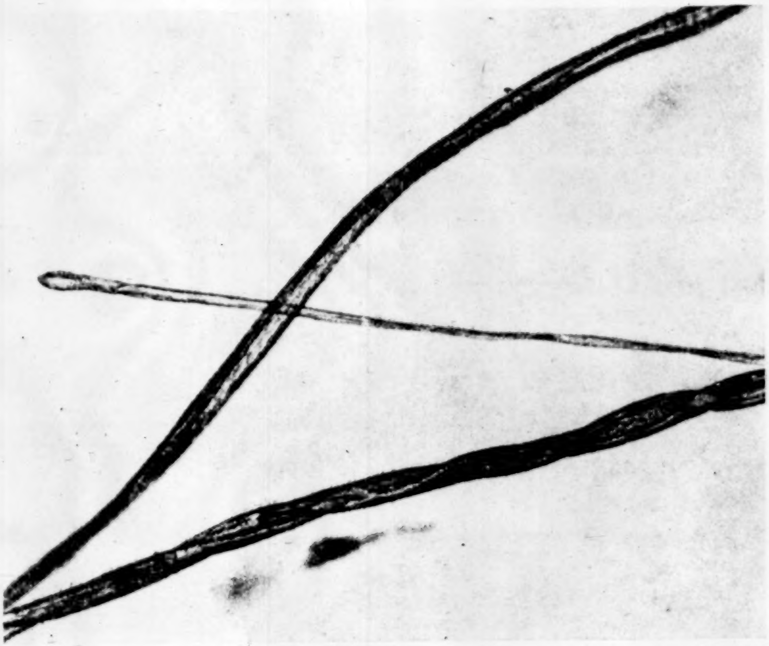

FIG. 1.—Longitudinal View of Cotton (× 250).

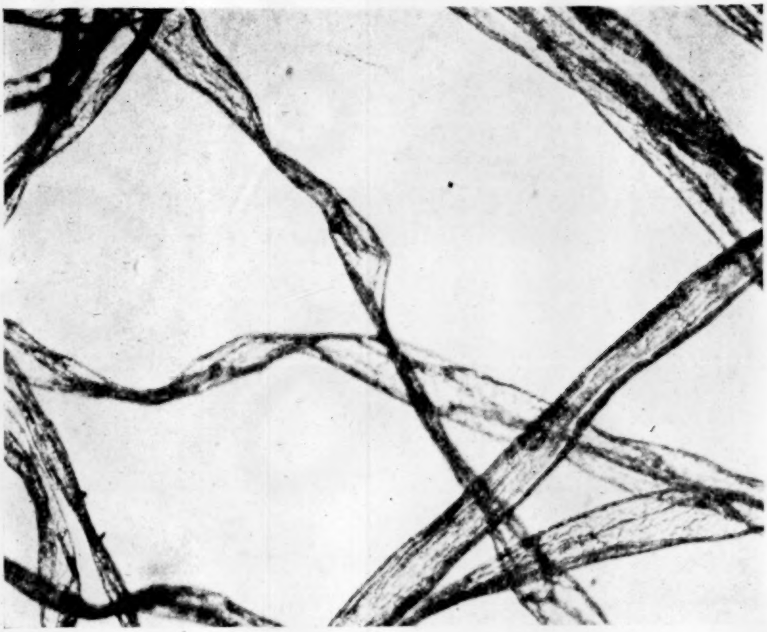

FIG. 2.—Longitudinal View of Immature Cotton (× 500).

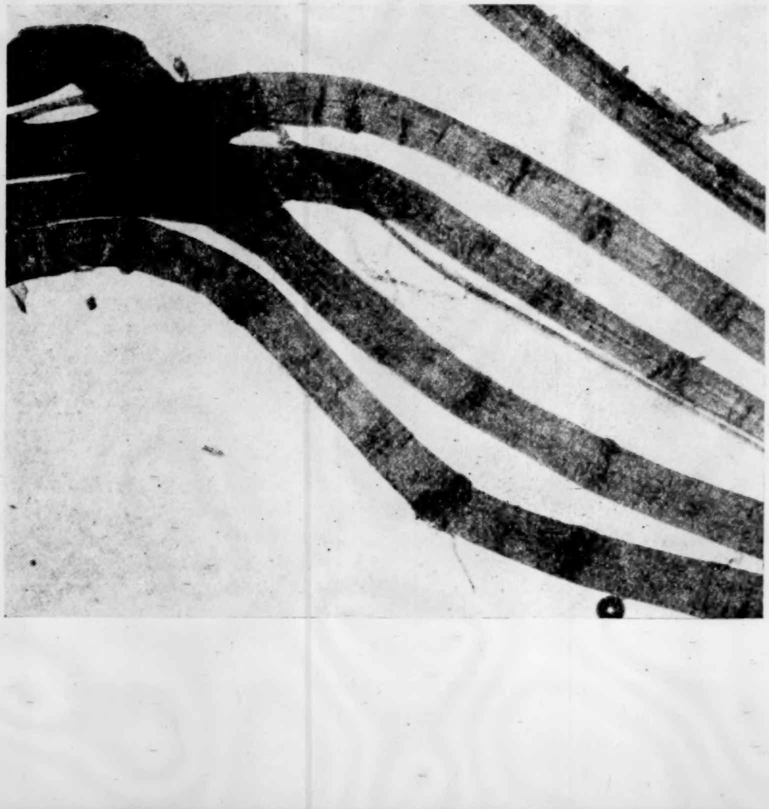

FIG. 3.—Longitudinal View of Flax or Linen Fibers (× 220).

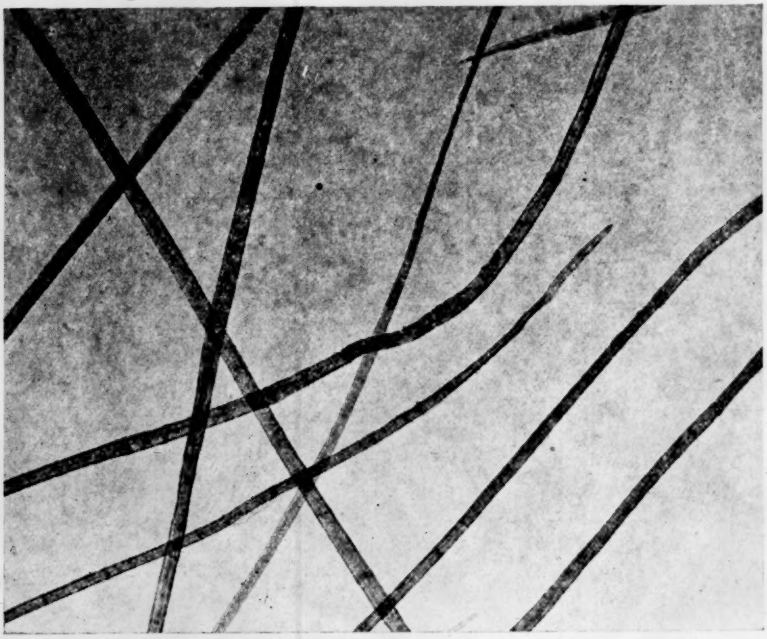

FIG. 4.—Longitudinal View of Hemp (*Cannabis Sativa*) (× 100).

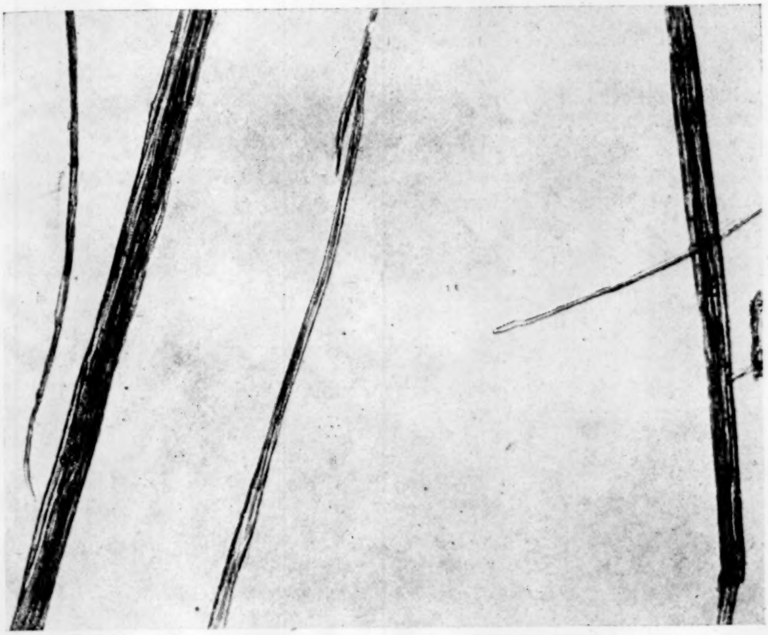

FIG. 6.—Longitudinal View of Jute (× 100).

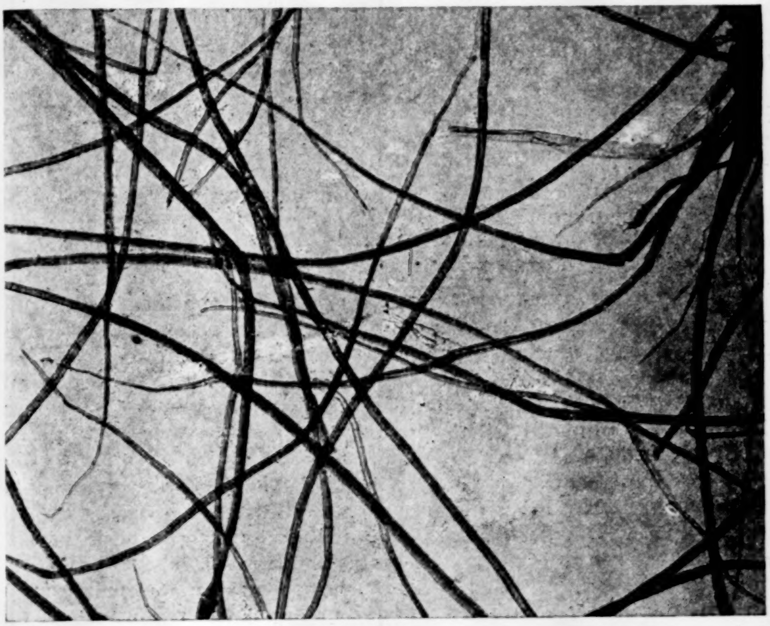

FIG. 5—Longitudinal View of Jute (× 100).

pronounced longitudinal striations, and cross lines are prominent, as are dislocations or folds, swellings and cross fissures. The fiber cross-sections are irregularly oval; the lumen flattened and irregular.

The commercial fibers are usually 1 to 2 yd. in length and in some kinds may be even longer.

There are numerous other fibers classed as hemp; such as, Sunn hemp, Manila hemp, Mauritius hemp, New Zealand hemp, etc., but which differ botanically from common hemp in various ways.

Jute:

Jute fibers appear as bundles of fibers, shorter than hemp, with tapering and more pointed ends than hemp. The lumen is oval shaped, almost central, large and well defined, at times as wide or wider than the cell-walls and often remarkably constricted. The cross-sections of the cells are polygonal, five or six sided. There are longitudinal striations but no transverse markings nor jointed ridges. Externally the fibers are smooth and lustrous.

The prepared fibers may run from 4½ to 8 ft. in length and the crude fibers may be as long as 14 ft.

Ramie (Rhea):

Ramie fibers are long, somewhat tapering cells of uneven diameter with thick rounded ends. The diameter is irregular and the central canal or medullary space is sometimes quite distinct and at other times disappearing entirely. The canals are filled with granular matter and occupy from one-third to one-half the diameter. In cross-section the cells are more or less irregularly elliptical, but are often flattened and show very characteristic prominent cross-lines or fissures. The cell-walls are coarse, thickened irregularly at intervals, usually exhibiting well-marked nodes, joints, and discolorations. There are many prominent deep longitudinal striations, crossed at irregular intervals.

Ramie is stronger than the other vegetable fibers but lacks their extensibility and flexibility.

Wool:

Wool hairs under the microscope show an outer scaly layer or cuticle and an inner fibrous layer or cortex which may or may not be pigmented, and a central canal or medulla, usually filled with more or less interrupted granular-appearing matter. The epidermal scales on the surface of the fiber can be readily discerned, even under low power magnification and these instantly distinguish the fiber from silk or vegetable fibers. The scales are more or less translucent in appearance and permit of the under cortical layer being seen through them. The nature, structure, and arrangement of the scales differ considerably with different varieties of wool. The epidermal layer of scales imparts to the wool fiber its characteristic quality of luster through the reflection of light from the surface.

The cortical layer or true fibrous portion of the fiber forms the major constituent of wool. It consists mainly of more or less elongated cells and often presents a distinctly striated appearance, the striations being visible through the translucent layers of scales. When fiber is fine in staple, the cortical cells exhibit more or less unevenness in their growth and arrangement, with the result that the fiber is contracted on one side or the other, causing the wavy appearance of such wools. Coarse wools seldom exhibit the wavy structure.

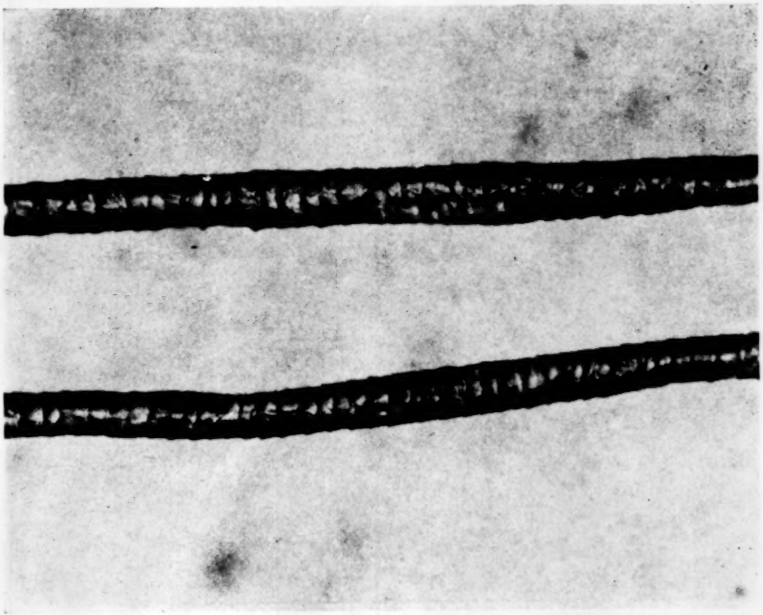

FIG. 8.—Longitudinal View of Wool (× 250).

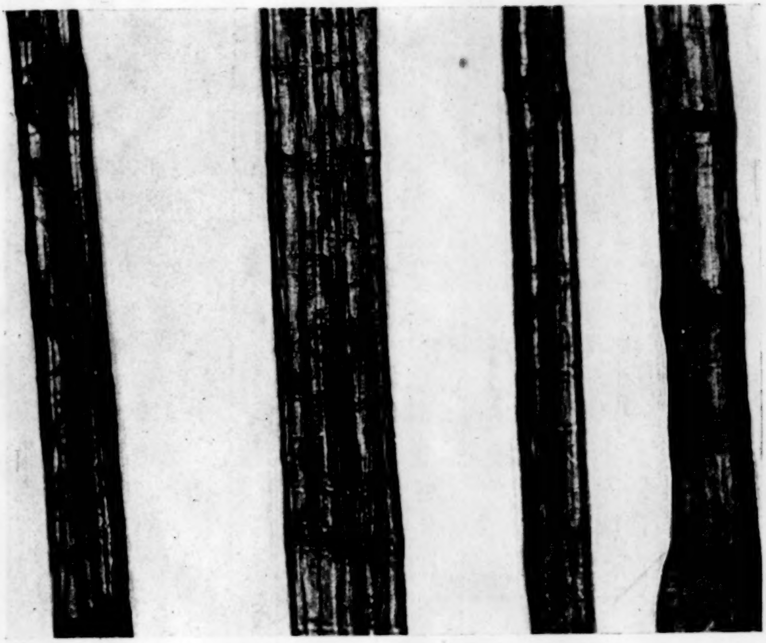

FIG. 7.—Longitudinal View of Ramie (× 250).

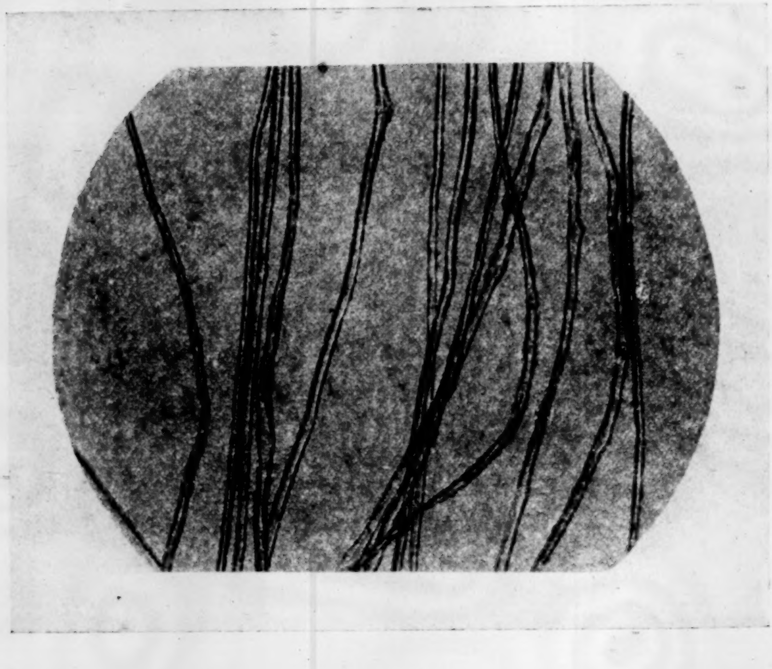

FIG. 9.—Longitudinal View of Silk (× 100).

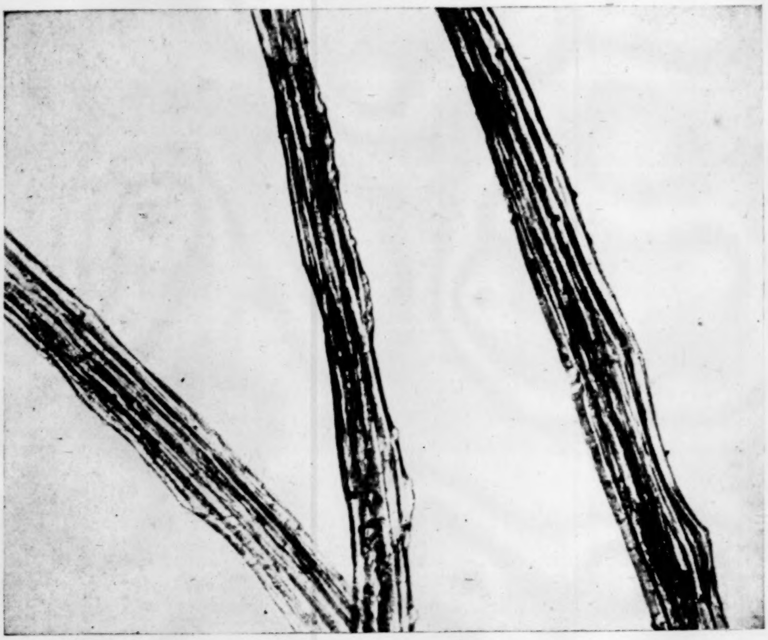

FIG. 10.—Longitudinal View of Raw Jap Silk (× 100).

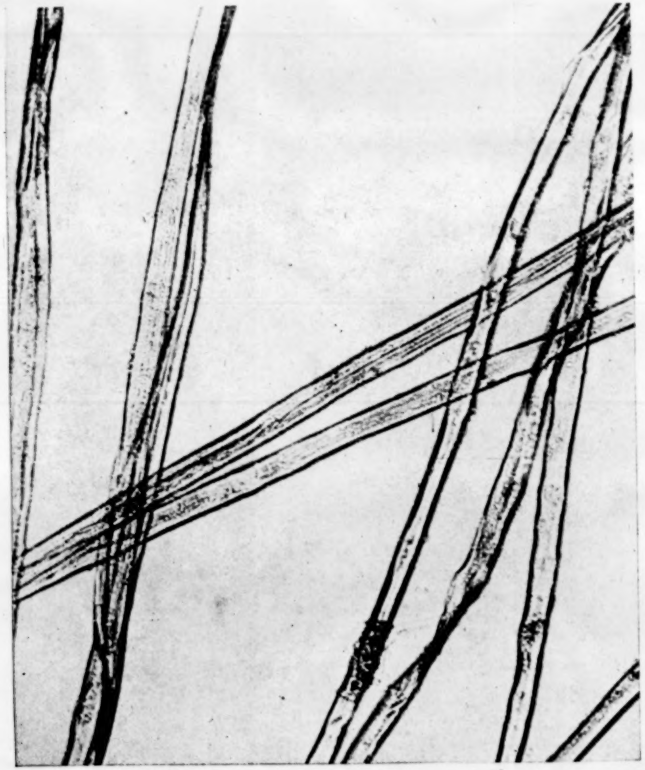

FIG. 11.—Longitudinal View of Tussah Silk (× 100).

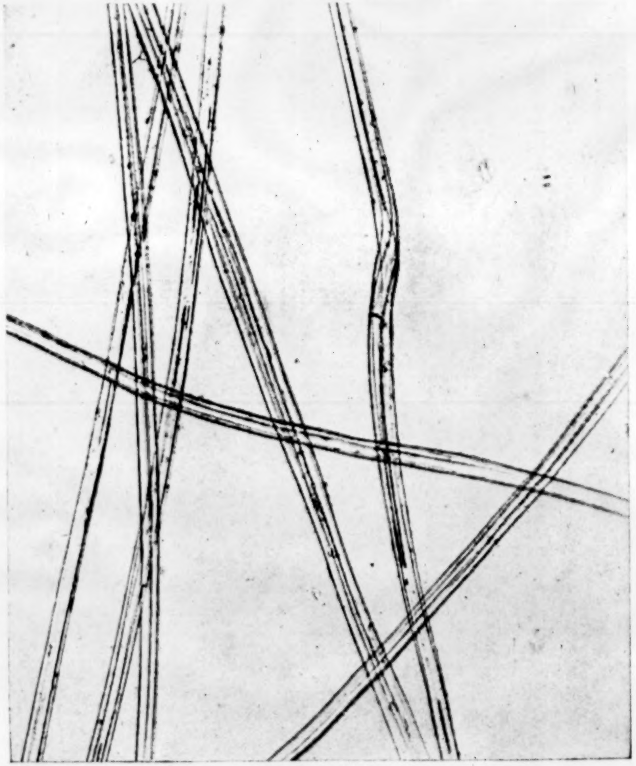

FIG. 12.—Longitudinal View of Cellulose Acetate Rayon (Celanese) (× 100).

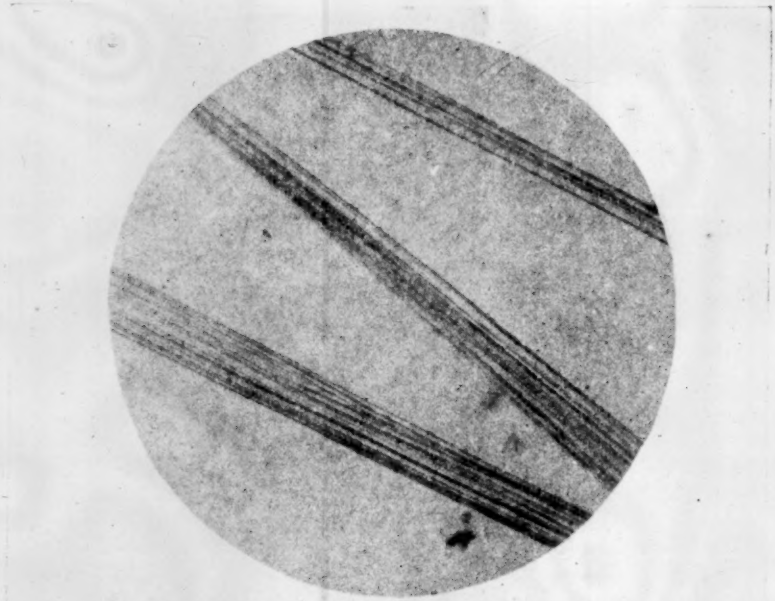

FIG. 13.—Longitudinal View of Xanthate of Cellulose Rayon (Viscose Co.) (× 100).

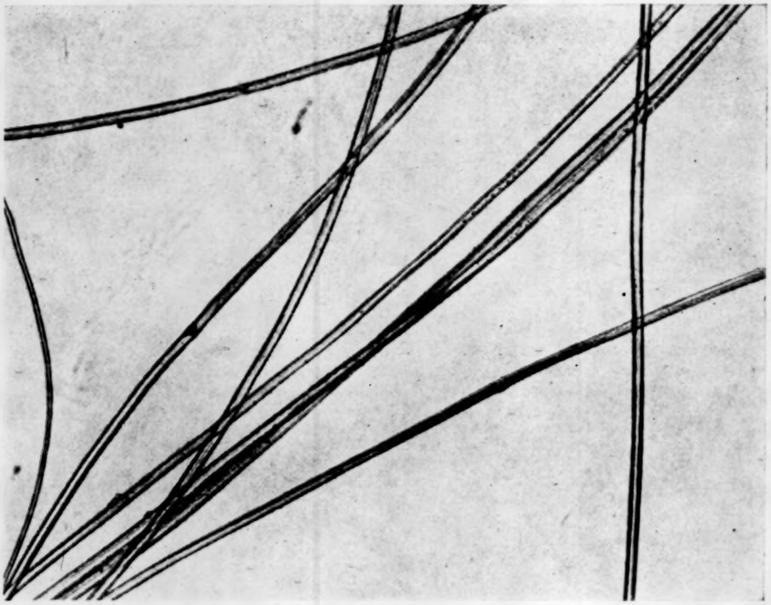

FIG. 14.—Longitudinal View of Cuprammonium Rayon (Bemberg) (× 100).

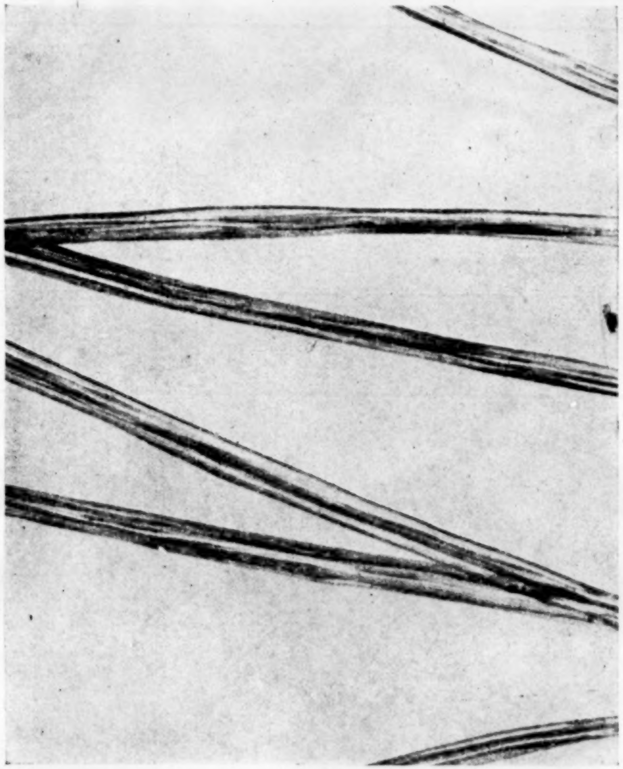

FIG. 15.—Longitudinal View of Nitro-cellulose Rayon (Tubize) (× 100).

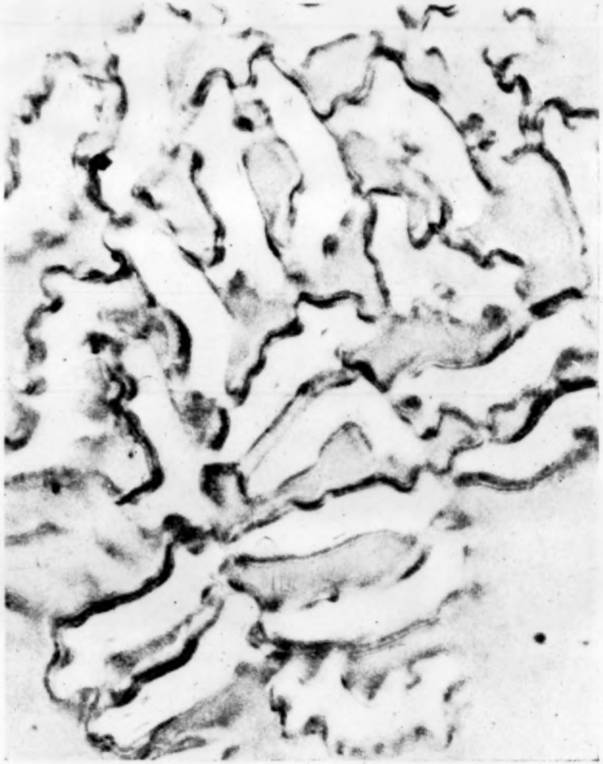

FIG. 16.—Cross-Section of Viscose Rayon, 150 Denier (DuPont Unbleached) (× 500).

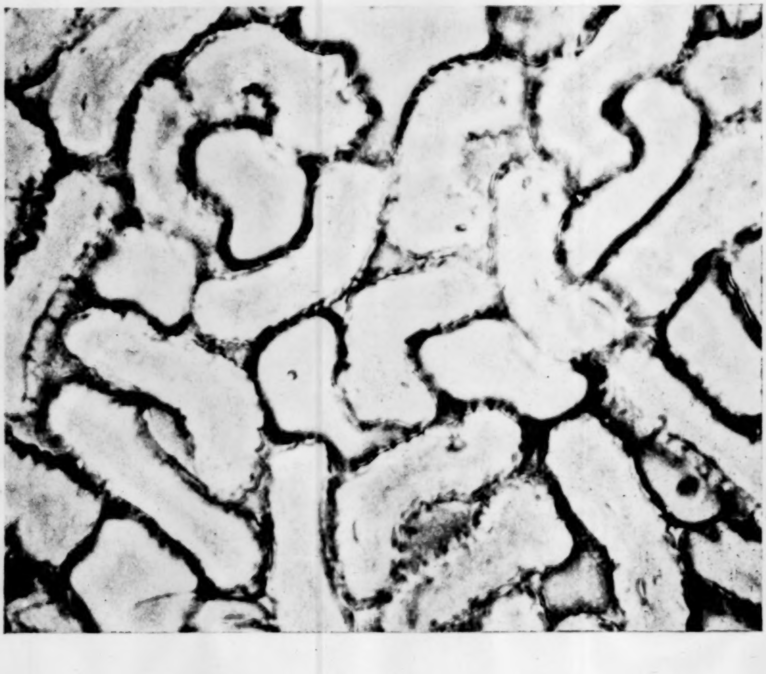

FIG. 17.—Cross-Section of Viscose Rayon, 300 Denier (Industrial Fiber Co.) (× 500).

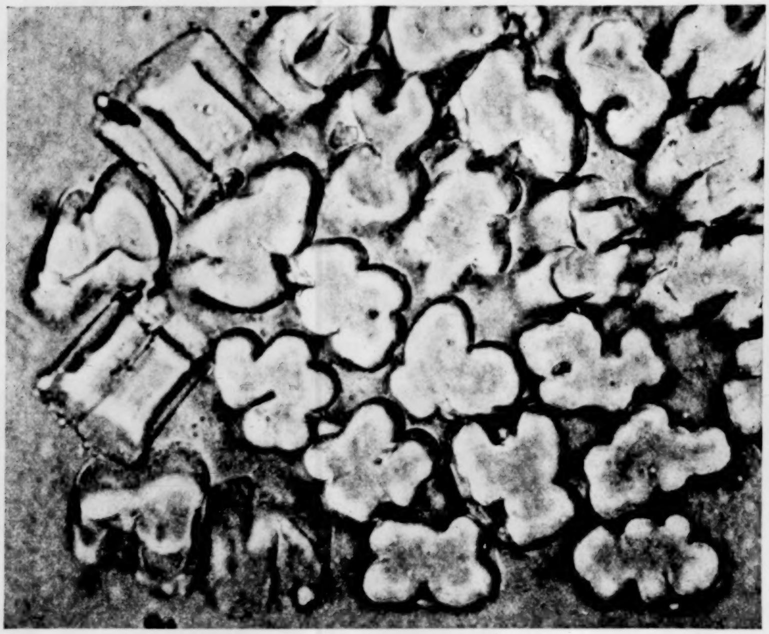

FIG. 18.—Cross-Section of Acetate Rayon, 150 Denier (Celanese) (× 500).

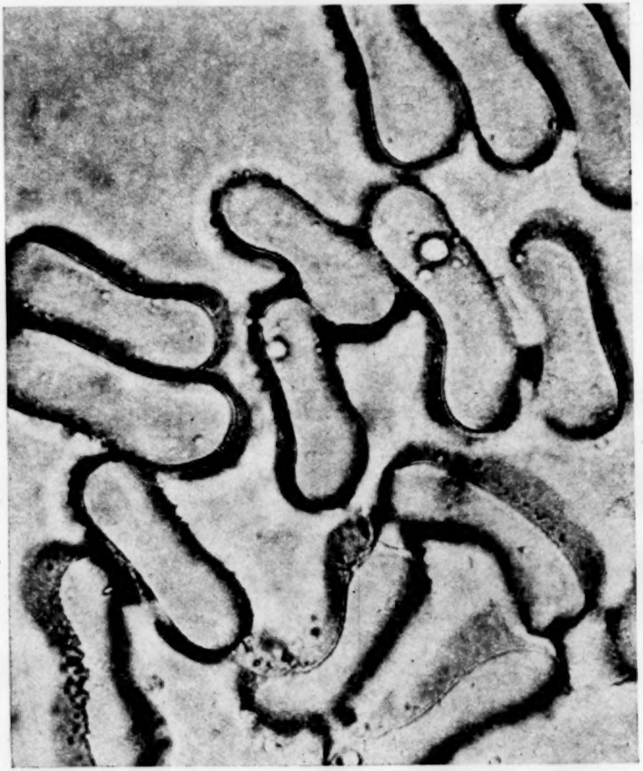

FIG. 19.—Cross-Section of Acetate Rayon, 150 Denier (Lustron Co.) (× 500).

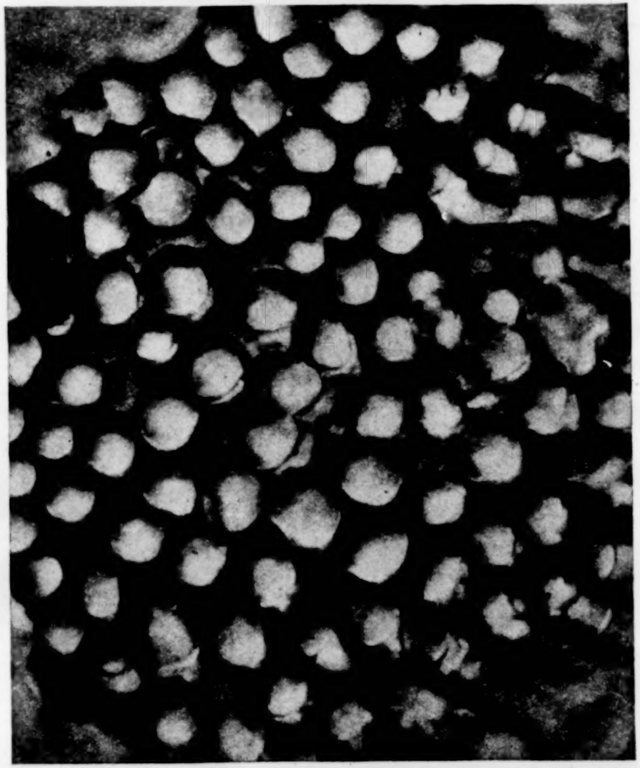

FIG. 20.—Cross-Section of Cuprammonium Rayon, 150 Denier (Bemberg) (× 500).

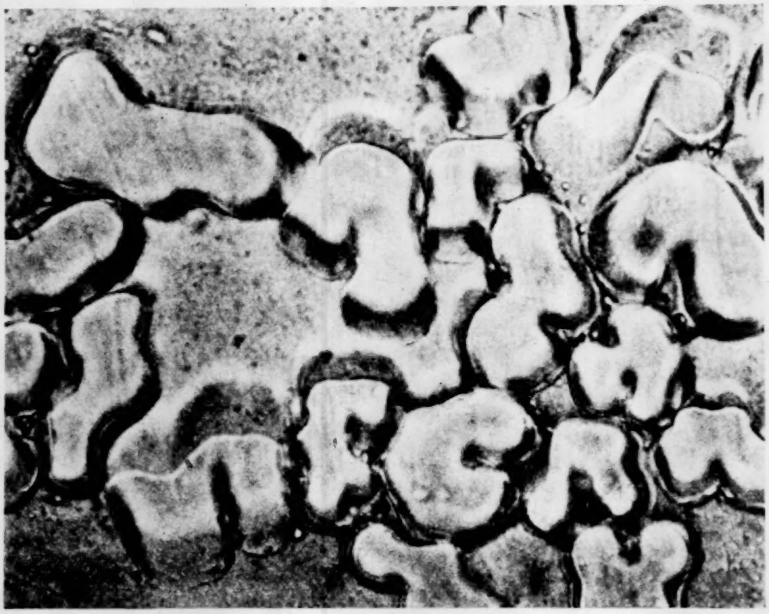

FIG. 21.—Cross-Section of Nitro-cellulose Rayon, 150 Denier (Tubize) (× 500).

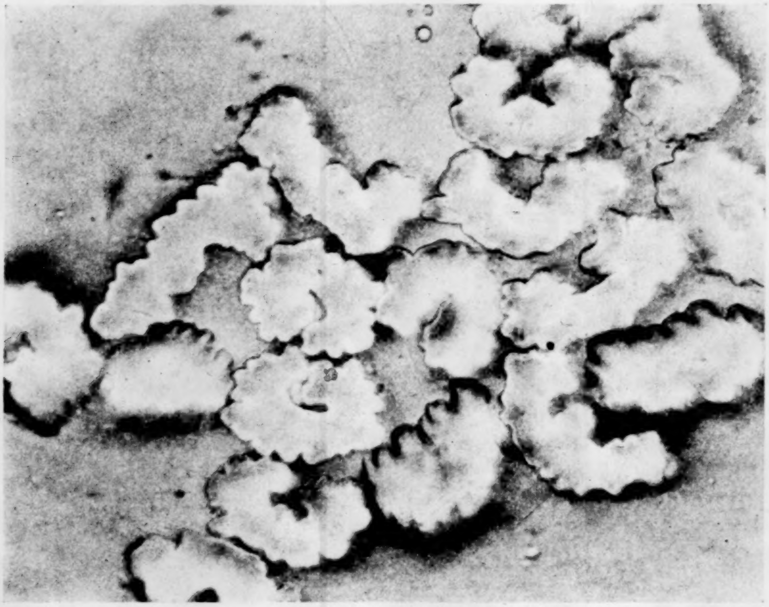

FIG. 22.—Cross-Section of Viscose Rayon, 150 Denier (Viscose Co.) (× 500).

Silk:

Silk filaments after de-gumming have the appearance of a single, fine, structureless, cylindrical, transparent filament (rarely striated longitudinally), flattened in spots, and in cross-section round or irregularly oval.

The fibers are many hundreds of yards long.

Wild Silk (Tussah Silk):

Wild silk consists of flattened, ribbon-like filaments of much greater width than the mulberry silk, with many fine, longitudinal striations, and with frequent oblique depressions where the fibers have crossed one another in the cocoons. Such silks are obtained from a variety of species of silk worms other than those from which the cultivated silk (*Bombyx mori*) is obtained. The silks are usually brownish in color.

Rayons:

Viscose rayons appear to consist of ribbons scored with deep longitudinal striations. The cross-section of the filaments varies from irregular ovals to long and narrow figures which may be either straight or bent with rounded crescents. The ends of the figure are rounded, the sides are scored by notches corresponding to the longitudinal striations of the filament.

Cuprammonium (or cuprate) rayons appear as smooth rods quite uniform in diameter with sometimes fine longitudinal striations. The cross-section is oval or round.

Nitro-cellulose or collodion rayons appear as if composed of several very fine filaments which adhere to each other throughout their length. The cross-section appears as rounded figures attached to one another.

Acetate rayons appear as transparent structureless filaments with only fine striations. The cross-sections are ovals which are flattened or indented at several points or sides.

FIBER MICROSCOPY

Fiber microscopy requires a certain amount of delicate technique and skill and a knowledge of proper methods of preparing and mounting specimens for examination as well as of the proper selection of lenses. Care and skill resulting from considerable practice are required to bring out the markings and structure of the various fibers.

Microscope.—A reasonably good microscope together with a good system of first-class lenses is essential. The following table gives a suitable range of magnifications obtained from the objectives and eyepieces noted:

	MAGNIFICATION	
OBJECTIVE	EYE-PIECE NO. 5	EYE-PIECE NO. 10
4 mm	200	400
8 mm	100	200
16 mm	50	100

It is an advantage to have the microscope fitted with a revolving nose-piece suitable for the three objectives, in which case the specimen can be readily located and viewed under different magnifications. An adjustable stage is also a convenience in locating different portions of the mount as well as in focussing. With a sub-stage diaphragm and condenser, proper conditions of illumination can be easily obtained. These are usually supplied with a good microscope.

Mounting of Specimens.—For all practical purposes and where it is not necessary to preserve the slides with their mounts, the specimens may be mounted in water. A few fibers should be well separated or teased with suitable implements and cut in convenient lengths, if necessary, after which they are laid on the slide and moistened with a drop of water. The cover-glass is placed over them and gently pressed down so as to flatten the specimen. It is usually preferable to confine the specimen to few rather than many fibers in order to avoid tangles and distortion. If permanent mounts are desired the fibers may be mounted in Canada Balsam which dries and cements the cover-glass firmly in place. Such mounting, however, is not recommended until considerable experience in fiber microscopy has been gained.

QUANTITATIVE SEPARATION OF THE MOST COMMON TEXTILE FIBERS

SELECTIVE DYEING TESTS FOR QUALITATIVE IDENTIFICATION

When little or nothing is known concerning the fibers present in a sample it will be found desirable to first apply the following selective dyeing tests, which will indicate qualitatively the nature of the fibers present, after which more definite qualitative and finally quantitative tests may be applied.

Stripping of Sample.—If the fibers have already been dyed when received, the dye should be stripped off before making the test. This can usually be accomplished by boiling in a 3-per-cent solution of sodium hydrosulfite. After the color has been stripped, wash the material thoroughly with water to remove the stripping agent. All percentages given are based on the weight of the goods dyed.

Treat a piece of the sample in a solution of NaCl (3-per-cent) and Newport Direct Sky Blue FF (3-per-cent). Viscose takes a full shade of blue, while cellulose acetate is undyed.

Dye a piece of the sample at boiling for 30 minutes in a dye bath containing 1 per cent of indigo carmine and 2 per cent of acetic acid. Work the goods thoroughly while dyeing, then remove and wash well with water. Wool or silk take a full shade, while cotton and rayon are undyed.

Dye a piece of goods for 45 minutes just under boiling temperature in a bath containing 2 per cent of National Superchrome Red B

(National Aniline and Chemical Co.) and 1.5 per cent of acetic acid. Then add 2 per cent of $K_2Cr_2O_7$ and boil for 30 minutes. Remove from the bath and wash thoroughly with water. Wool takes a full red shade while silk is undyed.

PROCEDURE FOR A COMPLETE QUANTITATIVE ANALYSIS

This procedure is for use in cases where an exhaustive knowledge of the several different fibers present in a sample is desired. In most cases, where not more than two different fibers are present in a sample and their identities are known qualitatively, the proper individual quantitative test may be advantageously applied directly, without first going through the general procedure.

PROCEDURE

Weigh out 2 to 5 g. of the sample in a glass-stoppered weighing bottle and dry at 100 to 110° C. to constant weight. The difference between the initial and final weights represents the moisture content. Boil the dry material thoroughly in dilute HCl (1-per-cent), care being taken not to disintegrate the fibers. If the fibers are much weakened or disintegrated, repeat with a new sample, using a weaker acid. Repeat the boiling with fresh portions of the acid until no residue is found upon evaporating a few drops of the liquid on a watch-glass. This treatment removes mineral loading matter soluble in HCl, finishing materials, more or less dyestuffs, as well as other material soluble in water.

Extract the residue first with alcohol and finally with carbon tetrachloride (CCl_4) until all soluble material is removed. Dry and weigh. Discard the extract. The residue is anhydrous fibers and any matter (mineral) not soluble in HCl. Divide immediately into two parts, and weigh each portion.

Reduce the first portion to ash. This will give the natural insoluble ash of the fibers, which is generally negligible, and any insoluble salts employed in mordanting or loading.

Heat to boiling about 60 cc. of basic $ZnCl_2$ solution, and immerse the second portion of the fibers. Remove the flame, stir the sample thoroughly for about one minute and again bring to boiling. Transfer immediately to a weighed Gooch crucible using the insoluble fibers as a mat for the crucible. Remove the insoluble fibers to a beaker containing cold, dilute HCl (5-per-cent). Thoroughly wash in the beaker by agitation and again filter. Repeat the process several times, using a weaker acid solution at each subsequent washing. Finally, remove the crucible and finish washing with several portions of hot water until free from chlorine as chloride. Dry at 100 to 105° C. and weigh.

The loss represents silk and in certain cases a portion of the sizing material. Also rayon or artificial silk is here removed.

Treat the residue with about 100 cc. of a solution of approximately 5-per-cent KOH and boil gently for 10 to 15 minutes. Pour into 500 cc. of cold water and let stand until the fibers have settled, and decant carefully the supernatant liquor, taking care to avoid loss of any fibers. Filter through a weighed Gooch crucible and wash thoroughly with boiling water. Moisten with a few cubic centimeters of dilute acetic acid and again wash with hot water, and finally with about 10 cc. of alcohol. Dry and weigh.

The loss in weight represents wool and a small portion of cotton. To correct for this add 3 per cent of the cotton to the cotton figure and subtract the same amount from the wool figure.

The residue is cotton or vegetable fibers (wood fiber, jute, linen, and similar material). Ignite. The loss represents the various vegetable fibers. The residue may consist of asbestos, mineral wool, or other mineral fibers, and should be examined qualitatively and microscopically.

QUANTITATIVE SEPARATIONS OF SAMPLES CONTAINING TWO OR MORE KINDS OF FIBERS

In all of the test procedures described below, all weighings are made on bone-dry material and losses are calculated on the original weight. For all practical purposes, the results so obtained are sufficiently reliable. However, where strictly commercially interpretable results are desired, the procedure must be followed after first correcting the bone-dry percentages to air-dry percentages, assuming the following standard regains at normal atmosphere:

	Standard Regains at Normal Atmosphere, per cent	Normal Regain Factor
Wool	14.0	$\frac{100}{114} = 0.877$
Rayon	11.5	$\frac{100}{111.5} = 0.897$
Silk	11.0	$\frac{100}{111} = 0.900$
Cotton and Cellulose Acetate	6.5	$\frac{100}{106.5} = 0.939$

Example.—A sample shows by analysis on a bone-dry basis:

Cotton	30.0 per cent
Wool	45.0 " "
Silk	25.0 " "
Total	100.0 per cent

Divide these percentages by their respective normal regain factors and obtain values in proportion to the normal atmosphere weights of these materials:

Cotton	$30.0 \div 0.939 = 32.0$
Wool	$45.0 \div 0.877 = 51.3$
Silk	$25.0 \div 0.900 = 27.8$
Total	111.1

By multiplying by $\frac{100}{111.1}$ there is obtained a total percentage of one hundred, and the component percentages are, therefore, the proportions of each fiber present in the material, on a basis of the proper normal regains, as follows:

Cotton	$32.0 \times \frac{100}{111.1} = 28.8$ per cent
Wool	$51.3 \times \frac{100}{111.1} = 46.2$ " "
Silk	$27.8 \times \frac{100}{111.1} = 25.0$ " "
Total	$= 100.0$ per cent

DETERMINATION OF MOISTURE AND SIZE LOSSES

In all of the following quantitative separations the standard procedure for determining the moisture and size losses is as follows and will not be repeated:

Weigh out 2 to 5 g. of the sample in a glass-stoppered bottle and dry at 100 to 110° C. to constant weight. The difference between the initial and final weights represents the moisture content, calculated as a percentage of the original weight. Remove the sizing materials from the residue by boiling with HCl solution (1-per-cent). Wash out the acid with water and dry at 105° C. to get the total weight of the fibers.

COTTON AND WOOL MIXTURES

PRELIMINARY

Weigh out a piece of the goods and dye it in a bath containing 3 per cent of indigo carmine and 2 per cent of acetic acid (both percentages based on the weight of the goods). Dye at boiling temperature for about 15 minutes, washing the goods thoroughly in the bath. The cotton will take a pale blue color and the wool will dye a much deeper blue. By examining the dyed cloth under a hand glass, a good approximation of the amount of wool present may be obtained.

PROCEDURE

Method A: Wool Content over 15 to 20 per cent:

Boil a known weight of the bone-dried and desized sample for 15 to 20 minutes with 5-per-cent KOH. Pour into 500 cc. of cold water, let settle, and decant the supernatant liquor. Filter through a weighed Gooch crucible and wash with hot water. Moisten with a few cubic centimeters of dilute acetic acid, again wash with hot water, and then with 10 cc. of alcohol. Dry and weigh. The difference between this weight and the weight of sample taken is the amount of wool plus 3 per cent of the cotton. To correct for this add 3 per cent of the cotton to the cotton figure and subtract the same amount from the wool figure.

Method B: Wool Content under 15 to 20 per cent:

Place a known weight of the sample in a considerable volume of a solution made by slowly stirring 80 cc. of concentrated H_2SO_4 (sp. gr. 1.84) into 25 cc. of water, previously cooled to room temperature. Work the sample in this mixture for about 15 minutes, removing it from time to time to another beaker and washing it with a stream of water to remove the slimy product formed by the action of H_2SO_4 on the cotton. Finally filter the residue into a weighed Gooch crucible, wash with water until entirely free from acid, dry in the oven at 100° C. and weigh the residue which in this case is wool.

COTTON, SILK, AND WOOL MIXTURES

The residue after removal of the sizing material is anhydrous fibers and any mineral matter not soluble in HCl. Divide immediately into two parts, weighing each.

Reduce the first portion to ash. This will give the natural insoluble ash of the fibers, which is generally negligible, and any insoluble salts employed in mordanting or loading.

Boil the second portion for 2 minutes in a solution of basic $ZnCl_2$ (sp. gr. 1.72), known as Elsner's reagent, which is prepared by dissolving 100 parts of $ZnCl_2$ and four parts of ZnO in 85 parts of hot water to complete solution. Wash the residue in dilute HCl and then in water until the acid has been completely removed as may be detected by litmus paper. The extract contains all the silk. The residue is cotton. Dry and weigh.

When only cotton and silk are present Method A as described under Cotton and Wool Mixtures should be used.

WOOL AND SILK MIXTURES

The residue after removal of the sizing material is anhydrous fibers and any mineral matter not soluble in HCl. Divide immediately into two parts, weighing each.

Reduce the first portion to ash. This will give the natural insoluble ash of the fibers, and any insoluble salts employed in mordanting or loading.

Dip the second portion in concentrated HCl for two minutes at 49° C. This will dissolve the silk and not materially affect the wool. Wash the residue well until all acid has been removed. Dry and weigh. The extract contains all the silk. The residue is wool.

SILK AND RAYON MIXTURES

Divide the residue after removal of sizing materials into two parts, weighing each.

Reduce the first portion to ash. This will give the natural insoluble ash of the fibers and any insoluble salts employed in mordanting or loading.

Treat the second portion at ordinary temperature for 20 minutes in an alkaline solution of copper sulfate known as Lowe's reagent, which is prepared by dissolving 10 g. of $CuSO_4 \cdot 5H_2O$ in 100 cc. of water, adding 5 cc. of glycerin and then adding a 20-per-cent caustic-soda solution until the precipitate formed redissolves. This will dissolve the natural silk, leaving the rayon as an insoluble residue. The extract contains all the silk. The residue is rayon.

ADDITIONAL TESTS FOR SILK AND RAYON MIXTURES

1. When treated with a cold semi-saturated solution of chromic acid silk is slowly soluble; all rayons except the acetate variety are soluble; while cotton and all other vegetable fibers are insoluble.

2. When treated with a 40-per-cent solution of potassium hydroxide, silk is acted upon at 65° C., dissolving at 85° C. and tussah silk swells at 75° C., dissolving at 120° C.; while rayons are insoluble on boiling.

3. In Schweitzer's reagent, silks, collodion and cellulose rayons are soluble, while gelatine rayon stains liquid-bright violet.

Schweitzer's Reagent:

Dissolve 5 g. of copper sulfate in 100 cc. of boiling water, add NaOH solution to complete precipitation; wash the precipitate thoroughly, then dissolve in the least quantity of NH_4OH. This should give a deep blue solution.

4. In Millon's Reagent a brick red color will develop with silk; while rayons remain white or uncolored.

Millon's Reagent:

Dissolve metallic mercury in its own weight of concentrated, c. p. HNO_3 (sp. gr. 1.42), then dilute this solution with an equal volume of water. Sometimes a new preparation of this reagent does not work (perhaps due to the nitric acid used), and so each lot should be tested by moistening scoured wool or real silk with it, gently warming and noting the production of a brick red color on the animal fiber. This reagent, if found reactive, should be kept in a small, tightly-stoppered bottle, when it will usually retain its staining power for a long time. It is used as a stain for animal fibers. The mixed or separated kinds of fibers are covered with a few drops of Millon's Reagent and gently warmed (not boiled).

TUSSAH SILK AND CULTIVATED MIXTURES

Divide the residue after removal of sizing materials into two parts, weighing each.

Reduce the first portion to ash. This will give the natural insoluble ash of the fibers, and any insoluble loading mordants, or tin salts.

Steep the second portion in cold concentrated HCl for 10 minutes, filter and wash the filter well with water until all acid has been removed, dry and reweigh. The extract contains all the silk. The residue is Tussah silk.

DIFFERENTIATION OF RAYONS

Samples tested by these methods shall be in the bleached or unbleached state and free from oil or other foreign substances.

To Distinguish Cellulose-Acetate from All Other Rayons

1. Twist fibers into a tight wad and then cautiously approach to a match flame, without being brought into contact with the flame.

Cellulose-acetate rayons melt or fuse, forming a black knob, or globule on the end, which precedes the small sputtering, relatively slow burning flame down the thread. If the flame be extinguished and the knob cooled, this will be found to be somewhat hard and resistant to crushing.

Nitro-cellulose, cuprammonium, and viscose rayons do not meltback but burn quietly and readily like bleached cotton fibers and the odor from the fumes is the same as that coming from burned cotton.

2. Treat the sample with pure acetone:

Cellulose-acetate rayon is soluble up to 1 per cent while nitrocellulose, cuprammonium, and viscose rayons are insoluble.

3. Treat the sample with glacial acetic acid (water white):

Cellulose-acetate rayon dissolves, and on adding water precipitates as a milky unstable emulsion or translucent gelatinous material.

Nitro-cellulose, cuprammonium, and viscose rayons are all insoluble.

TO DISTINGUISH NITRO-CELLULOSE RAYONS FROM VISCOSE AND CUPRAMMONIUM RAYONS

Treat the water-moistened yarn with a 1-per-cent solution of diphenylamine in concentrated H_2SO_4 (sp. gr. 1.84):

Nitro-cellulose rayon immediately assumes a blue color and dissolves in a few seconds, yielding a blue coloration.

Cuprammonium, and viscose rayons are not colored blue.

TO DISTINGUISH CUPRAMMONIUM RAYONS FROM VISCOSE RAYONS

1. Prepare a bath containing 1 per cent of the sample weight, of Pontamine Scarlet B or equivalent colors, using 0.5 g. per 200 cc. of water. Immerse samples into liquor simultaneously, heating to 65° C. for 10 minutes. The samples may then be washed thoroughly and compared wet or dry:

The cuprammonium rayons stain heavier, and the viscose rayons lighter.

2. Place 5 g. of the unknown sample of rayon (viscose or cuprammonium), together with 100 cc. of water and 3 cc. of concentrated H_2SO_4 (sp. gr. 1.84), in a flask, the mouth of which is covered with a piece of filter paper which has been saturated with a 10-per-cent solution of lead acetate; then place the flask over a moderately boiling steam bath for 4 hours. If at the end of this period the exposed part of the lead acetate paper becomes stained with a brown or black color, the rayon is viscose rayon; if no coloration is obtained the sample is cuprammonium rayon.

TENTATIVE DEFINITIONS OF TERMS RELATING TO TEXTILE MATERIALS[1]

Serial Designation: D 123 - 27 T

This is a **Tentative Standard,** published for the purpose of eliciting criticism and suggestions, and as such is subject to annual revision.

ISSUED, 1926; REVISED, 1927.

(*A*) *Imperfections*

Loop Knot.—Snarl or curl produced by a weft yarn receding upon itself.

(*B*) *General Definitions*

Regain (*Moisture Regain*).—The percentage of moisture present in a textile material calculated on its absolute dry weight.

Gage.—In the case of knit goods, the closeness of the wales, that is, the longitudinal row of loops per inch, a measure of the fineness of the fabric. It is expressed by the number of needles in 1½ in.

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[1] Criticisms of these Tentative Definitions are solicited and should be directed to Mr. K. B. Cook, Secretary of Committee D-13 on Textile Materials, Winnsboro Mills, Winnsboro, S. C.

These tentative definitions, when adopted as standard, will be added to the present Standard Definitions of Terms Relating to Textile Materials (Serial Designation: D 123), 1927 Book of A.S.T.M. Standards, Part II.

TENTATIVE METHODS OF TENSION TESTING OF METALLIC MATERIALS[1]

Serial Designation: E 8 - 27 T

This is **a Tentative Standard,** published for the purpose of eliciting criticism and suggestions, and as such is subject to annual revision.

ISSUED, 1924; REVISED, 1925, 1927.

These methods deal with the form and dimensions, the machining, and the testing of tension test specimens of metallic materials. Such matters as methods of taking samples from which to prepare test specimens are treated in the individual specifications for ferrous metals and for non-ferrous metals.

TEST SPECIMENS

1. In recommending the following specimens for use in tension tests it is not intended to exclude entirely the use of other test specimens for special materials or for special forms of material; for example, in tests of tubing and pipe the form of specimen recommended for plate, shape and flat material (Fig. 1) is not generally suitable for use, and a special form of specimen is specified. It is, however, recommended that wherever it is feasible the specimens here recommended be used.

Wire, Rods and Pipe.

2. Tension test specimens of wire are of the full-size diameter as drawn, and tension test specimens of rods of ductile metal are often of the full-size diameter as rolled. Tension test specimens of pipe and of tubing are frequently of full size as manufactured, in which case the ends should be plugged with metal plugs which do not extend within the gage marks.

Plates, Shapes and Flats.

3. The tension test specimen shown in Fig. 1 is recommended for plate, shape and flat material having a thickness of $\frac{1}{4}$ in. or over.[2] The thickness of the specimen is that of the material tested.

NOTE.—When it is desired to use a specimen with a gage length of less than 8 in., the general proportions of Fig. 1 should be followed. Specimens with a gage length of 2 in. are occasionally used. When it is not convenient to machine specimens to the standard shape shown in Fig. 1, specimens may be used with edges machined parallel for the entire length of the specimen. If such specimens are machined with a tool cutting across the edges of the specimen it is important that the transverse tool marks be removed before the specimen is tested.

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[1] Criticisms of these Tentative Methods are solicited and should be directed to Mr. H. F. Moore, Chairman of Technical Committee I, of Committee E-1, on Mechanical Testing, University of Illinois, Urbana, Ill.

These tentative methods are in effect a revision of the Methods for Tension Tests of the Standard Methods of Mechanical Testing of Metallic Materials. The standard methods, which were last published under the Serial Designation: E 1 - 18, have accordingly been withdrawn.

[2] Attention is called to the fact that two types of specimen are applicable for material $\frac{1}{4}$ in. in thickness, the plate specimen shown in Fig. 1 and the thin sheet specimen shown in Fig. 3.

For thick plate material, it is usually preferable to use a machined specimen rather than to use a specimen the full thickness of the plate.

4. For tension tests of wrought ferrous and non-ferrous metal in the form of plate, sheet, flat wire,[1] strip,[1] band,[1] and hoop[1] without respect to width,[1] length, grade or method of manufacture, and having a thickness from 0.01 in. to 0.250 in., the test specimen described in Sections 5 and 6 is recommended.

NOTE.—This specimen may also be used in tests of material cut from tubing.

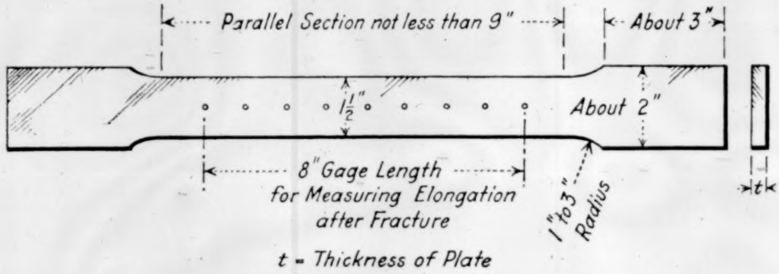
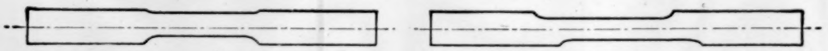
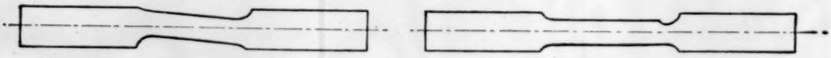

Parallel Section not less than 9"
About 3"
$1\frac{1}{2}$"
About 2"
8" Gage Length for Measuring Elongation after Fracture
1" to 3" Radius
t
t = Thickness of Plate

FIG. 1.—Tension Test Specimen for Plate Material.



(a) Ends not Symmetrical with Reduced Section.

(b) Two Sides of Reduced Section not Symmetrical.



(c) Ends not Parallel to Reduced Section.

(d) Narrow Width Due to "Hogging In" of Cutter.

FIG. 2.—Common Errors in Preparation of Plate or Sheet Metal Test Specimens.

5. The specimen blank shall be cut from the material to be tested, having its length in such direction relative to the material as may be specified. The specimen blank shall conform to the dimensions shown in the following table:

METHOD OF CUTTING LONG EDGES OF BLANK	NOMINAL THICKNESS OF MATERIAL, IN.	MINIMUM WIDTH OF BLANK, IN.
Sheared	Up to $\frac{1}{8}$, incl.	$\frac{3}{4}$
Sheared	Over $\frac{1}{8}$ to $\frac{1}{4}$, incl.	1
Sawed[a]	Up to $\frac{1}{4}$, incl.	$\frac{3}{4}$

[a] Or otherwise machined without severely straining the metal.

Blanks cut with a torch shall not be used unless all metal affected by such cutting is removed by machining.

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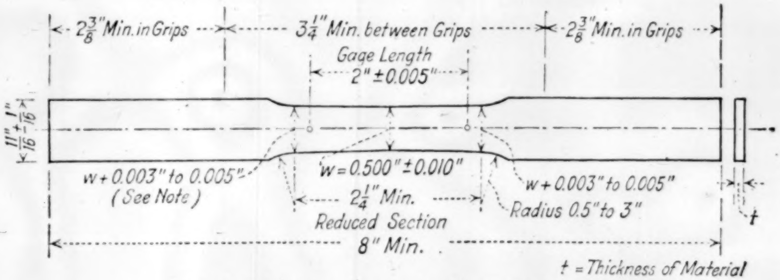
[1] It is to be noted that the recommended specimen cannot be used for flat wire, strip, band, or hoop material whose width is less than the end width of the specimen itself.

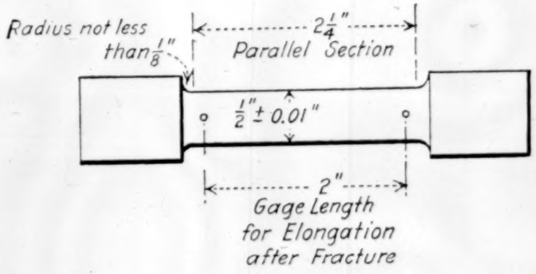
6. Figure 3 shows the form of the finished specimen recommended for thin sheet metals. The reduced section of the specimen shall be machined in such a manner as to avoid leaving severe machining strains in the material. It is essential that the reduced section and the ends of the specimen be symmetrical with respect to the longitudinal axis of the specimen.[1]

In Fig. 3, the 2-in. gage length should be laid off with a tolerance in length of ±0.005 in.


$2\frac{3}{8}''$ Min. in Grips
$3\frac{1}{4}''$ Min. between Grips
$2\frac{3}{8}''$ Min. in Grips
Gage Length
$2'' \pm 0.005''$
$\frac{11''}{16} \pm \frac{1''}{16}$
$w + 0.003''$ to $0.005''$
(See Note)
$w = 0.500'' \pm 0.010''$
$2\frac{1}{4}''$ Min.
Reduced Section
$w + 0.003''$ to $0.005''$
Radius $0.5''$ to $3''$
$8''$ Min.
t
t = Thickness of Material

Note: Gradual Taper from Ends of Reduced Section to Middle.
All Machining Dimensions are Shown below and Testing Dimensions above Specimen.

FIG. 3.—Standard Tension Test Specimen for Thin Sheet Metals.


Radius not less than $\frac{1}{8}''$
$2\frac{1}{4}''$
Parallel Section
$\frac{1}{2}'' \pm 0.01''$
$2''$
Gage Length for Elongation after Fracture

Note:-The Gage Length, Parallel Section, and Fillets shall be as Shown, but the Ends may be of any Shape to fit the Holders of the Testing Machine in such a Way that the Load shall be axial.

FIG. 4.—Standard 2-in. Tension Test Specimen.

7. The tension test specimen shown in Fig. 4 is recommended for general use in testing metals.[2] The gage length for measuring elongation after fracture is 2 in.

8. When it is necessary to cut specimens from material (other than plate, shape and flat material) which is of such size that the specimen shown in Fig. 4 cannot be used, it is recommended that a specimen with dimensions proportional to those shown in Fig. 4 be used and that the specimen be made as large as feasible. In any such small-size

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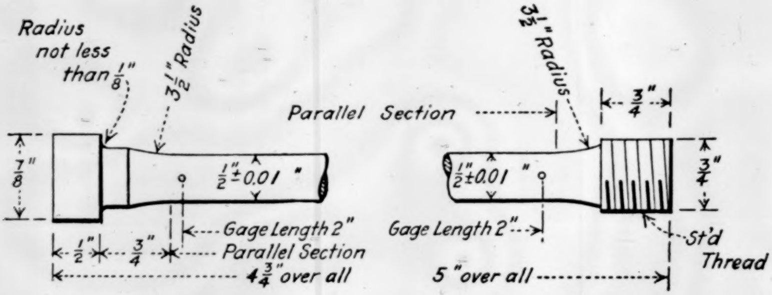
[1] For all specimens for flat metallic materials, both for thin sheet and for thick plate, it is important to so machine the specimen as to avoid the conditions shown in Fig. 2.

[2] **Attention is called to Section 10.**

specimen it is especially important that the gage length for measuring elongation be four times the diameter of the specimen.

Measurement of Cross-Section.

9. In all tension tests of metals the actual dimensions of cross-section of the test specimens shall be measured with a micrometer reading to $\frac{1}{200}$ of the dimension measured, and the stresses shall be computed on the basis of the measured cross-section; it should never


Radius not less than $\frac{1}{8}$"
$3\frac{1}{2}$" Radius
Parallel Section
$\frac{7}{8}$"
$\frac{1}{2}$" ± 0.01 "
Gage Length 2"
$\frac{1}{2}$"
$\frac{3}{4}$"
Parallel Section
$4\frac{3}{4}$" over all
$3\frac{1}{2}$" Radius
$\frac{3}{4}$"
$\frac{1}{2}$" ± 0.01 "
$\frac{3}{4}$"
Gage Length 2"
5 " over all
St'd Thread

(*a*) Specimen with shouldered ends. (*b*) Specimen with threaded ends.

FIG. 5

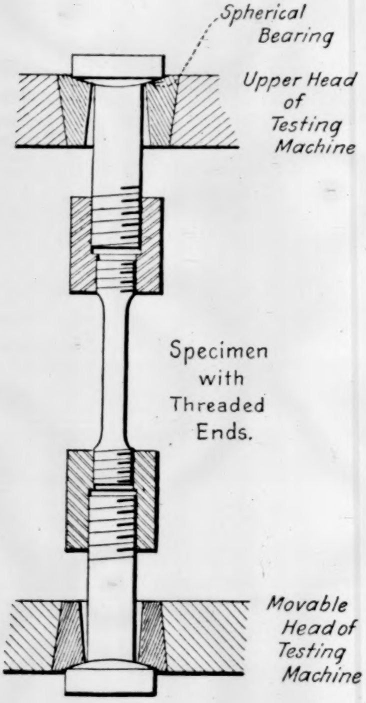

Spherical Bearing
Upper Head of Testing Machine
Specimen with Threaded Ends.
Movable Head of Testing Machine

FIG. 6

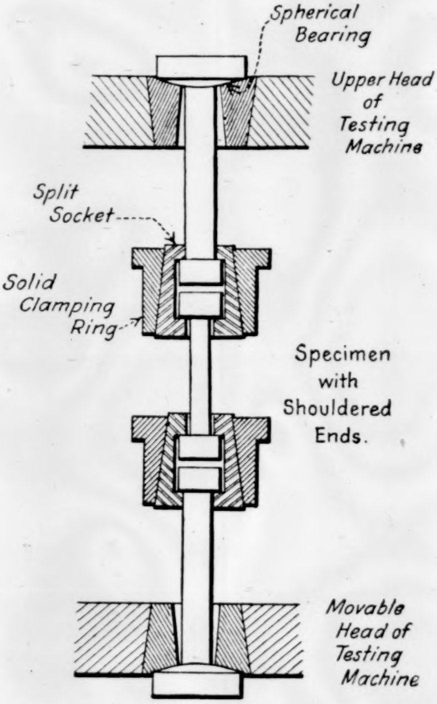

Spherical Bearing
Upper Head of Testing Machine
Split Socket
Solid Clamping Ring
Specimen with Shouldered Ends.
Movable Head of Testing Machine

FIG. 7

be assumed that the dimensions of the measured cross-section are identical with the nominal dimensions.

NOTE.—It will be noted that the tolerance for diameter of specimens shown in Fig. 4 permits the use of specimens 0.505 in. in diameter.

Ends. 10. The shape of the ends of the specimen shown in Fig. 4 are not specified above. For specimens of brittle metal it is desirable that the diameter of the specimen be changed gradually along its length from the minimum section at the gage length to the diameter at the ends. Fig. 5 shows two forms of end of specimen which have given satisfactory results in tests of brittle metals.

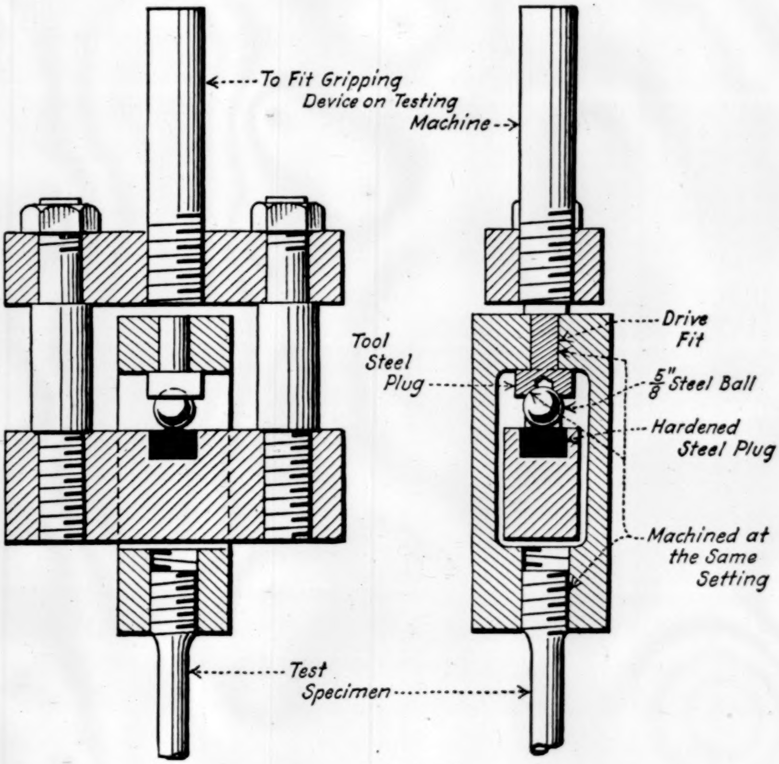

To Fit Gripping Device on Testing Machine
Tool Steel Plug
Drive Fit
$\frac{5}{8}$" Steel Ball
Hardened Steel Plug
Machined at the Same Setting
Test Specimen

FIG. 8

The gripping device is shown as used with threaded end specimens. A similar device fitted with split sockets would be used with shouldered specimens.

Finish. 11. Specimens shall be finished so that the surfaces are smooth and free from nicks and tool marks. All ragged edges shall be smoothed.

GRIPPING DEVICES FOR TENSION TEST SPECIMENS

Wedge Grips. 12. For long bars of ductile metal and for the flat plate test specimen shown in Fig. 1, wedge grips, bearing directly on the end of the test specimen, generally furnish a satisfactory means of gripping the specimens.

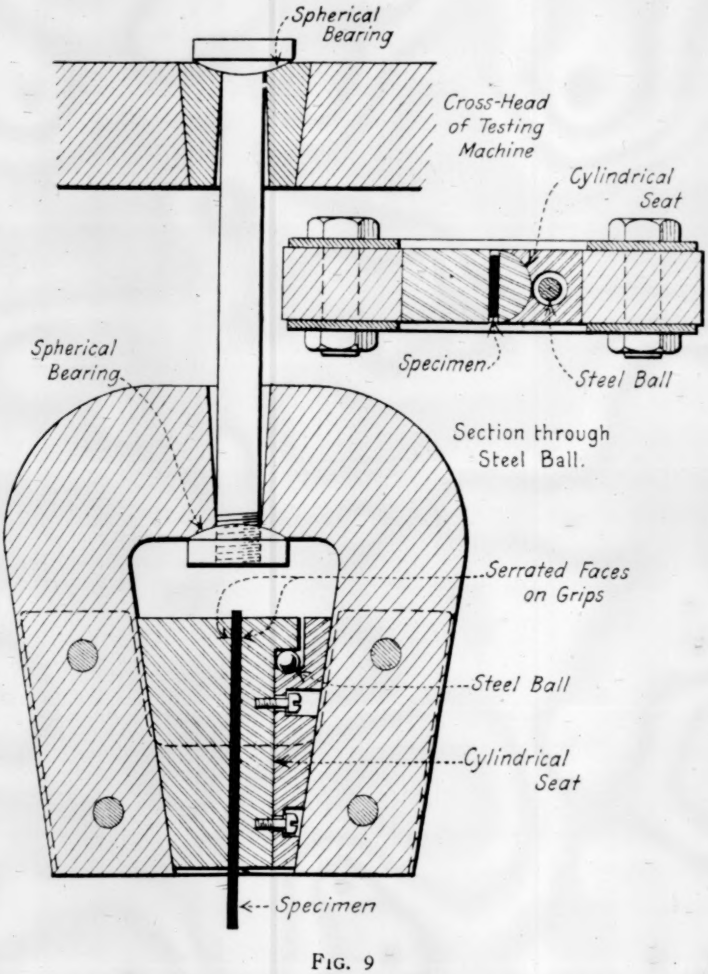

Spherical Bearing
Cross-Head of Testing Machine
Cylindrical Seat
Specimen
Steel Ball
Section through Steel Ball.
Spherical Bearing
Serrated Faces on Grips
Steel Ball
Cylindrical Seat
Specimen

FIG. 9

Grips for Brittle Material. 13. For short specimens and for specimens of brittle material, wedge grips are not a satisfactory means of holding test specimens; it is necessary to use machined specimens and to use special means for insuring that the specimen, when under load, shall be as nearly as possible in pure axial tension. Fig. 6 shows a device for gripping tension specimens with threaded ends and Fig. 7 shows a device for gripping specimens with shouldered ends. Both these gripping devices are attached to the heads of the testing machine through spherical-seated bearings. The distance between spherical bearings should be as great as is feasible. For brittle materials, even the spherical-seated bearings shown in Figs. 6 and 7 are not always effective in avoiding bending stress on the specimen. The gripping device shown in Fig. 8 has proved satisfactory for testing such specimens, and is an excellent gripping device for any machined tension test specimen.

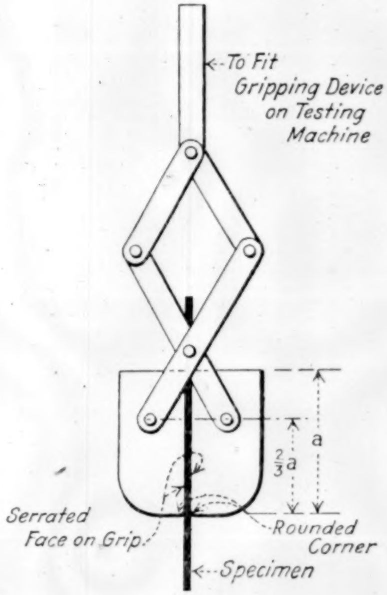


FIG. 10

14. For specimens cut from thin plate material and from sheet material, ordinary wedge grips are liable to cut the specimens near the edges, giving a tearing stress rather than an axial tension. The self-adjusting grips shown in Fig. 9 have proved satisfactory for tests of thin sheet copper and aluminum. **Grips for Sheet Material.**

15. For tests of specimens of wire, ordinary wedge grips are liable to cut the wire at the edges of the grips. This cutting has been found to be largely eliminated by the use of grips of the form shown in Fig. 10. **Grips for Wire.**

16. In making tension tests, care shall be taken to see that the **Alignment.**

axis of the test specimen is located in the center line of the heads of the testing machine and that the liners used behind wedge grips are of proper thickness. From time to time the openings in the heads of the testing machine shall be lined up and the heads tested for parallelism. Deviations from correct alignment and from parallelism should not exceed 0.01 in. for any position of the movable head within the range of movement during test. The heads of the machine should be free from sidewise motion that is visible to the unaided eye as the machine is run at its fastest speed.

SPEED OF OPERATION OF TESTING MACHINE

17. The pulling speed has a marked influence on the tensile properties shown by materials tested, an increase in speed increasing the values found for yield point and tensile strength. In testing specimens of metallic materials in gage lengths of 2 and 8 in., the speed of the machine, by which is meant the speed of the cross-head when the machine is running idle, shall conform to the following requirements:

The speed of head of the testing machine shall be such that the load can be accurately weighed, but in no case shall the speed be greater than the values given in the following table, which values represent the extreme of good laboratory practice for steel:[1]

Specified Minimum Tensile Strength of Material, lb. per sq. in.	Gage Length, in.	Maximum Cross-head Speed, in. per minute	
		Yield Point	Tensile Strength
80 000 or under	2	0.50	2.0
	8	2.00	6.0
Over 80 000	2	0.25	1.0
	8	0.50	2.0

18. In determining the elastic limit in accordance with Method I, Section 20, the cross-head speed for the 2-in. gage length shall not exceed 0.125 in. per minute.

19. In determining the elastic limit by Method II, Section 20, the cross-head speed shall not exceed 0.025 in. per inch of gage length per minute.

DETERMINATION OF ELASTIC LIMIT, YIELD POINT, AND TENSILE STRENGTH

Elastic Limit.

20. The term "elastic limit" is defined as follows:

Elastic Limit.—The greatest stress which a material is capable of developing without a permanent deformation remaining upon complete release of the stress.

---

[1] The speeds given here are probably too high for satisfactory use in testing non-ferrous metals.

The determination of the elastic limit as thus defined would logically involve the application and release of a succession of increasing loads on a test specimen until there was observed deformation after release of a load. This procedure is very slow and since for many materials experience does not indicate any appreciable difference between the elastic limit and the limit of proportionality of stress to strain (sometimes called the proportional limit), the determination of the stress at the limit of proportionality of stress to strain is regarded as an accurate determination of the elastic limit.

It is obvious that the values obtained in tests for determining the elastic limit will depend on the delicacy of methods and instruments used. It becomes necessary, therefore, that in any test the method used in obtaining the elastic limit be clearly stated. The following methods are in common use for determining a value designated as the elastic limit.

Method I, proposed by Committee A-1 on Steel, and embodied in a number of specifications for steel. (For tension tests only.) The elastic limit shall be determined by an extensometer reading to 0.0002 in. The extensometer shall be attached to the specimen at the gage marks and not to the shoulders of the specimen nor to any part of the testing machine. When the specimen is in place and the extensometer attached, the testing machine shall be operated so as to increase the load on the specimen at a uniform rate. The observer shall watch the elongation of the specimen as shown by the extensometer and shall note, for this determination, the load at which the rate of elongation shows a sudden increase. The extensometer may then be removed from the specimen and the test continued to determine the tensile strength.

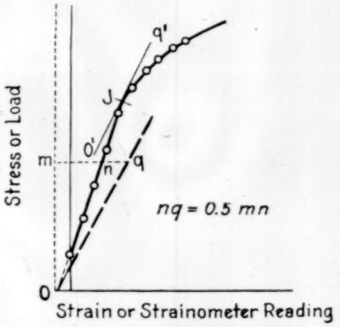


FIG. 11.—Illustrating Method II for Determining Elastic Limit.

Method II (proposed by the late J. B. Johnson) is a somewhat more delicate method for locating the elastic limit than is Method I. In Method II, the elastic limit shall be taken as that stress at which the rate of deformation is 50 per cent greater than the initial rate of deformation. A stress-strain diagram is necessary for determining the elastic limit by this method. It is illustrated in Fig. 11. The initial rate of deformation is given by the ratio $mn:Om$. $nq = 0.5\ mn$, $mq = 1.5\ mn$, and the slope of Oq represents a rate of deformation 50 per cent greater than the initial rate. $O'q'$ is drawn parallel to Oq and tangent to the stress-strain diagram. The point of tangency J locates the elastic limit. In using Method II the same precautions should be observed in attaching the strainometer as for the determination of the elastic limit by Method I. Method II, in tension tests of metals, gives lower values for the elastic limit than does Method I. It is recommended that in using Method II for tension tests the strainometer be of such sensitiveness that it will indicate a change of strain of 0.0001 in. per inch of gage length (0.0001 mm. per millimeter of gage length).

Methods of High Precision.—When it is desired to determine the elastic limit with a high degree of precision, it is suggested that the experimenter devise his own procedure, and in reporting his results describe the procedure in detail, including a statement of the limits of sensitiveness of the apparatus used and of the procedure used in plotting the stress-strain diagram from which the determination of elastic limit is made. It is to be remembered that the accurate determination of the elastic limit requires the use of accurate and sensitive instruments and the use of accurate methods of plotting test data.

Yield Point.

21. The term "yield point" is defined as follows:

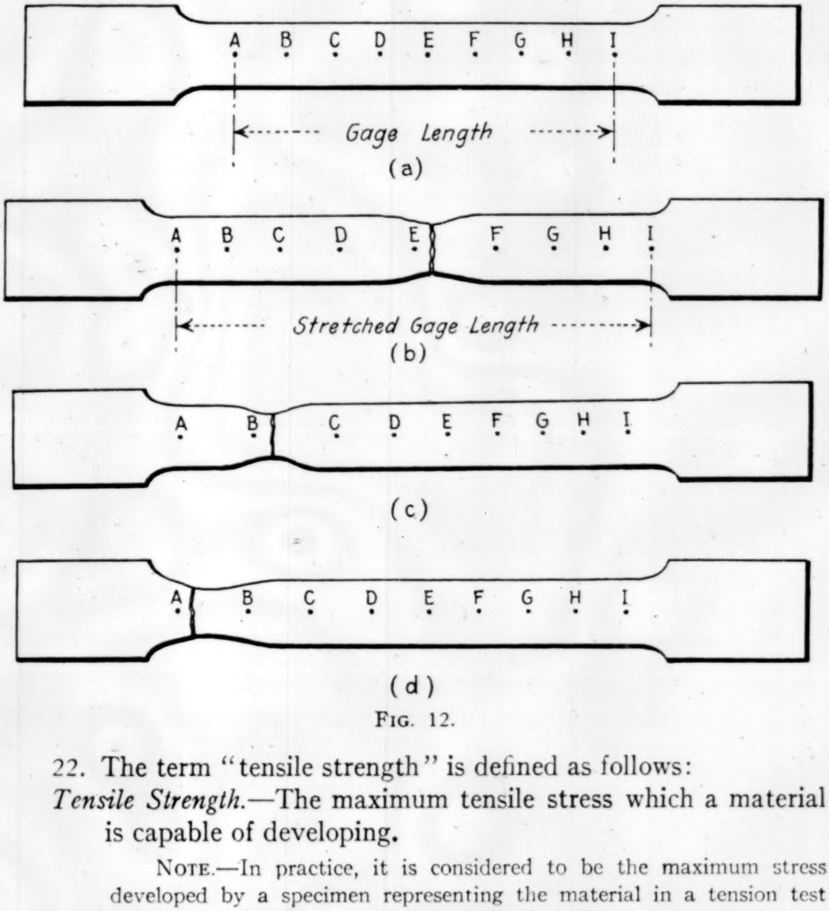
Yield Point.—The stress in a material at which there occurs a marked increase in strain without an increase in stress.

Two methods are in use for determining the yield point: (I) The "drop of the beam" method, and (II) the method by use of dividers:

Method I.—In Method I, load is applied to the specimen at a steady rate of increase and the operator keeps the beam in balance by running out the poise at a steady rate. At the yield point the increase of load stops (and for some metals there is an actual falling off of load), but the operator, running out the poise at a steady rate, runs it a trifle beyond the balance position, and the beam of the machine drops for a brief but appreciable interval of time. In a machine fitted with a self-indicating load-measuring device there is a sudden halt of the load-indicating pointer, corresponding to the drop of the beam. The load at the "halt" or the "drop" is recorded, and the corresponding stress is taken as the yield point. This method of determining the yield point requires only one man to conduct the test.

Method II.—In Method II an observer with a pair of dividers watches for visible elongation between two section marks on the specimens. When visible stretch is observed, the load at that instant is noted, and the stress corresponding to the load is taken as the yield point. When a strainometer[1] is used in place of dividers a deformation of 0.01 in. over a gage length of 2 in. shall be regarded as indicating the yield point.

Some metals do not have a well-defined yield point.



(a) (b) (c) (d)

FIG. 12.

Tensile Strength.

22. The term "tensile strength" is defined as follows:

Tensile Strength.—The maximum tensile stress which a material is capable of developing.

NOTE.—In practice, it is considered to be the maximum stress developed by a specimen representing the material in a tension test carried to rupture, under definite prescribed conditions. Tensile strength is computed from the maximum load carried during a tension test and the original cross-sectional area of the specimen.

The conditions that must be prescribed in a tension test of metallic materials are the form of specimen, the method of gripping the specimen, and the rate of application of load. These are covered in foregoing sections. No further detailed discussion of methods of determining tensile strength is necessary, as there is involved merely the observing and the recording of the maximum load carried by the specimen during the test.

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[1] The determination of yield point with a strainometer is sometimes made in tests on non-ferrous metals.

THE MEASUREMENT, AFTER FRACTURE, OF THE ELONGATION AND THE REDUCTION OF CROSS-SECTION OF TENSION TEST SPECIMENS

Elongation. 23. The measurement of the elongation after fracture of tension test specimens can be made with sufficient accuracy by means of a pair of dividers and a scale. The elongation should not be reported for any tension test specimen which breaks outside the middle third of the gage length.

NOTE.—If only a few specimens are furnished for testing it is recommended that in marking the gage length for measuring elongation after fracture it be divided into eight parts, and that if a specimen breaks inside the gage length but outside the middle third of the gage length the requirement in the foregoing paragraph be waived, and the elongation be measured and reported as follows:

(1) If the specimen breaks in the middle half of the gage length (between *C*) and *G*, Figs. 12 (*a*) and (*b*)) the elongation is measured directly over the stretched gage length (Fig. 12 (*b*).

(2) If the specimen breaks between *A* and *C* (or between *G* and *I*) but nearer *B* than *A* (or nearer *H* than *I*), as shown in Fig. 12 (*c*) the elongation from *A* to *C* (or from *G* to *I*) is measured, and to this is added *twice* the measured elongation from *C* to *F* (or from *D* to *G*).

(3) If the specimen breaks within one-half a division of an end gage mark (see Fig. 12 (*d*)) the elongation from *A* to *E* (or from *E* to *I*) is measured and multiplied by 2.

The above method can be applied to specimens with any gage length, and to turned specimens as well as flat specimens.

This method is not applicable to brass specimens.

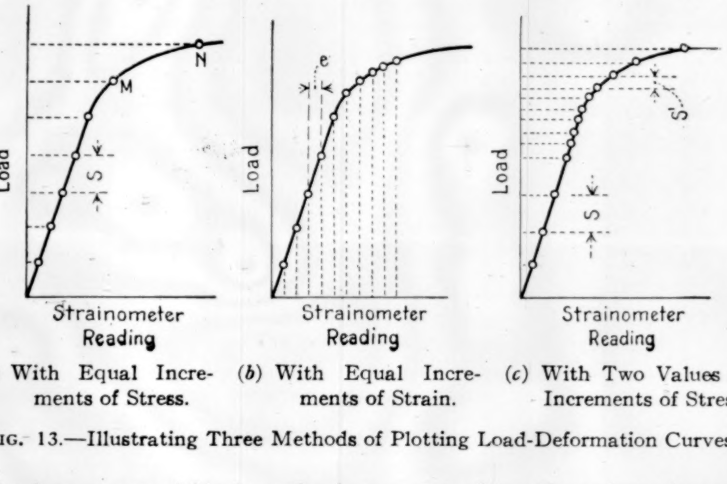
Reduction of Area. 24. The measurement of reduction of the dimensions of the cross-section of a tension test specimen may be made by the direct measurement with a micrometer of the smallest section of the fractured specimen. For round specimens this measurement can usually best be made by holding the broken pieces together in a vise or between centers and then measuring the average diameter of the smallest cross-section by means of a micrometer fitted with points so shaped that they will come in contact with the specimen at its smallest diameter.

PLOTTING STRESS-STRAIN DIAGRAMS

25. A stress-strain diagram is a diagram plotted with values of stress as ordinates and values of strain as abscissas.

NOTE.—The use of the term "stress-strain diagram" is frequently extended to cover diagrams plotted with values of applied load, or applied moment, as ordinates and with values of stretch, compression, deflection, or twist as abscissas.

Stress-strain diagrams are in some cases drawn directly by an autographic attachment to the testing machine. A more usual method of procedure consists in taking a series of load readings (from the balanced scale beam of the testing machine) with corresponding readings of the strain-indicating apparatus. The term "strainometer reading" will be used to denote the reading of the strain-measuring instrument. From these readings, or from values computed from them, there is plotted a diagram with stress-indicating values (load or stress) as ordinates, and strain-indicating values (elongation or strain) as abscissas. In planning such a test it is necessary to decide on the increment of load or the increment of reading of strainometer to be used between successive readings.



(*a*) With Equal Increments of Stress.
(*b*) With Equal Increments of Strain.
(*c*) With Two Values of Increments of Stress.

FIG. 13.—Illustrating Three Methods of Plotting Load-Deformation Curves.

In Fig. 13 are shown three typical stress-strain diagrams. The material for all three tests is the same, and the test specimens are all of the same size, so that the diagrams should be the same. The diagram shown in Fig. 13 (*a*) is plotted from points determined by taking increments of load (S). In this diagram it is seen that owing to the shape of the curve, data for locating points between M and N are lacking. That particular portion of the curve (the "knee" of the curve) is the part for which it is especially desirable to locate several points on the diagram.

In Fig. 13 (*b*) is shown a diagram plotted from points determined by taking increments of strainometer reading (e). It will be noted that for this diagram there are located several points near the knee of the curve, and the shape of the diagram in this important region is much more definitely determined than for the curve shown in Fig. 13 (*a*).

The custom of choosing increments of load rather than increments of strainometer reading is quite common in tests of materials and is followed because, in general, it is easier to compute increments of load than it is to compute increments of strainometer reading. An estimate of the load necessary to stress the specimen up to the knee of the curve is made and some fraction (frequently one-tenth) of this value is taken as an increment. The computation of the corresponding increment of strainometer reading is more complicated.

Sometimes the practice is followed of applying a few increments of load as determined above, and then applying load in much smaller increments (S') until the knee of the curve is passed. Fig. 13 (*c*) shows a diagram obtained in this manner. This method involves a marked increase in the number of readings necessary for a test and with unknown material there is always some danger that the knee of the curve will be reached before the use of small increments of load is begun.

The following method of choosing increments for a test is suggested: Estimate the load corresponding to the knee of the stress-strain diagram and choose a value for increment of load about one-tenth of this value. Apply this increment of load (S) once and note the corresponding change of reading for the strainometer (e). Then for the remainder of the test, use for the increment of strainometer reading a value which corresponds to some convenient interval on the scale of the strainometer, and which is approximately equal to (e).

TENTATIVE METHODS OF COMPRESSION TESTING OF METALLIC MATERIALS[1]

Serial Designation: E 9 - 27 T

This is a **Tentative Standard,** published for the purpose of eliciting criticism and suggestions, and as such is subject to annual revision.

ISSUED, 1924; REVISED, 1925, 1927.

These methods deal with the form and dimensions, the machining, and the testing of compression test specimens of metallic materials. Such matters as methods of taking samples from which to prepare test specimens are treated in the individual specifications for ferrous metals and for non-ferrous metals.

TEST SPECIMENS

1. In recommending the following specimens for use in compression tests it is not intended to exclude entirely the use of other test specimens for special materials or for special forms of material. It is, however, recommended that wherever it is feasible the specimens here recommended be used.

2. It is recommended that standard compression specimens be in the form of circular cylinders. The ends of a specimen should be plane, as nearly as can be determined by the use of a straight edge and the unaided eye. In most cases this requirement necessitates the turning or the grinding of the ends of the specimen.

3. There are recognized three classes of compression specimens for metallic materials, designated as short specimens, medium-length specimens, and long specimens, respectively. Short specimens are used for compression tests of such metals as bearing metals, which in service are used in the form of a thin plate or shell to carry load perpendicular to the surface. Medium-length specimens are used for determining the general compressive strength properties of metallic materials. Long specimens are best adapted for determining the modulus of elasticity in compression of metallic materials. In reporting the results of a compression test, it is important that the dimensions of the test specimen be given.

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[1] Criticisms of these Tentative Methods are solicited and should be directed to Mr. H. F. Moore, Chairman of Technical Committee I, of Committee E-1, on Mechanical Testing, University of Illinois, Urbana, Ill.

These tentative methods are in effect a revision of the Methods for Compression Tests of the Standard Methods of Mechanical Testing of Metallic Materials. The standard methods, which were last published under the Serial Designation: E 1 - 18, have accordingly been withdrawn.

4. Figure 1 shows the proportions of the three classes of compression specimens. Suggested dimensions for compression specimens for general use are:

Short specimens: $d = 1\frac{1}{8}$ in. ± 0.01 in. (area of cross-section is approximately 1 sq. in.), $h = 1$ in.;

Medium-length specimens: $d = 0.798$ in. ± 0.01 in., $h = 2\frac{3}{8}$ in., or
$d = 1$ in. ± 0.01 in., $h = 3$ in., or
$d = 1\frac{1}{8}$ in. ± 0.01 in., $h = 3\frac{3}{8}$ in.

Long specimens: $d = 1\frac{1}{4}$ in. ± 0.01 in., $h = 12\frac{1}{2}$ in.

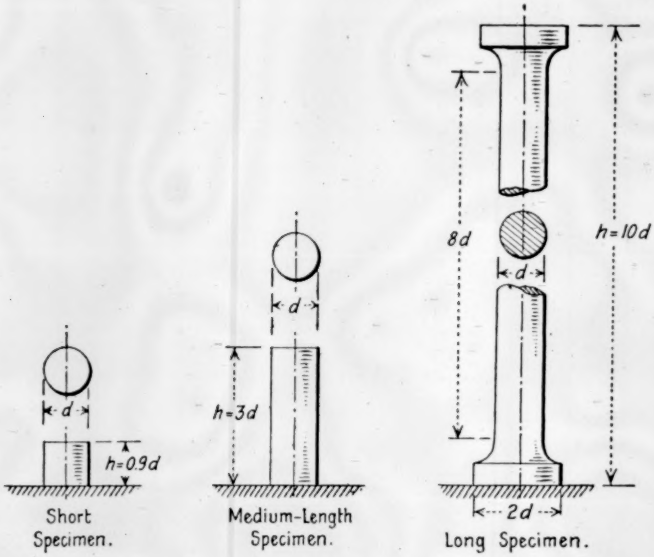

FIG. 1.

5. In all compression tests of metallic materials, the actual dimensions of cross-section of the test specimens shall be measured with a micrometer reading to $\frac{1}{200}$ of the dimension measured, and stresses shall be computed on the basis of the measured cross-section. It should never be assumed that the dimensions of the cross-section of the specimen are identical with the nominal dimensions.

6. Specimens shall be finished so that the surfaces are smooth and free from nicks and tool marks. All ragged edges shall be smoothed.

BEARING BLOCKS FOR COMPRESSION TEST SPECIMENS

7. Both ends of a compression test specimen shall bear on a carefully machined plane surface. The bearing blocks shall either be made of hardened steel, or shall be faced with hardened steel.

8. One end of a compression test specimen shall bear on a spherical-seated compression block.[1] Fig. 2 shows a satisfactory arrangement of compression specimens and bearing blocks. It is desirable that the spherical-seated bearing block be at the upper end of the test specimen (for specimens tested with the axis vertical). It is important that the center of the spherical surface of the spherical-seated bearing block should be in the flat face which bears on the specimen, otherwise lack of parallelism between faces of the specimen sets up a bending moment in the specimen.[2]

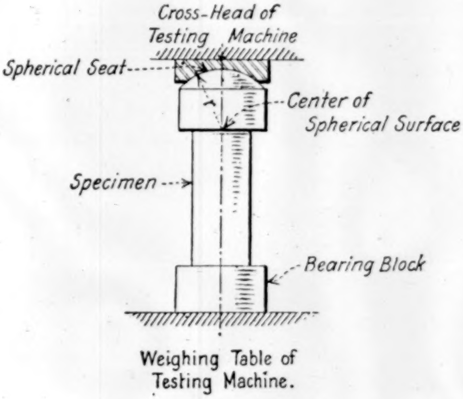
Cross-Head of Testing Machine
Spherical Seat
Center of Spherical Surface
Specimen
Bearing Block
Weighing Table of Testing Machine.

FIG. 2.

9. It should be borne in mind that the object of a spherical-seated bearing block is to give the specimen as even a distribution of initial load as is possible. Owing to friction, the spherical-seated bearing cannot be relied on to adjust itself to bending action which may occur during the test.

10. In making compression tests, care should be taken to preserve the alignment of the heads of the testing machine, and to center the specimen in the testing machine. From time to time the heads of the testing machine shall be tested for parallelism. Deviations from parallelism should not exceed 0.01 in. The movable head of the machine should be free from sidewise motion that is visible to the unaided eye as the machine is run at its fastest speed.

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[1] The device shown in Fig. 3 has been successfully used in compression tests of metallic specimens whose ends were machined with extreme care. It will be noted that this device does not involve a spherical seated compression block bearing directly on the test specimen. This device or one similar has been successfully used in the British National Physical Laboratory and in the laboratories of the U. S. Air Service at McCook Field, Dayton, Ohio.

[2] See Mont Schuyler, "Spherical Bearings," *Proceedings*, Am. Soc. Testing Mats., Vol. XIII, p. 1004 (1913).

SPEED OF OPERATION OF TESTING MACHINE

11. In making compression tests of specimens of metallic materials the speed of the machine, by which is meant the speed of the cross-head when the machine is running idle, shall be such that the load can be accurately weighed, but in no case shall the speed be greater than the values given in the following table:

LENGTH OF SPECIMEN, IN.	MAXIMUM CROSS-HEAD SPEED, IN. PER MINUTE
1.00	0.05
3.00 or greater	0.10

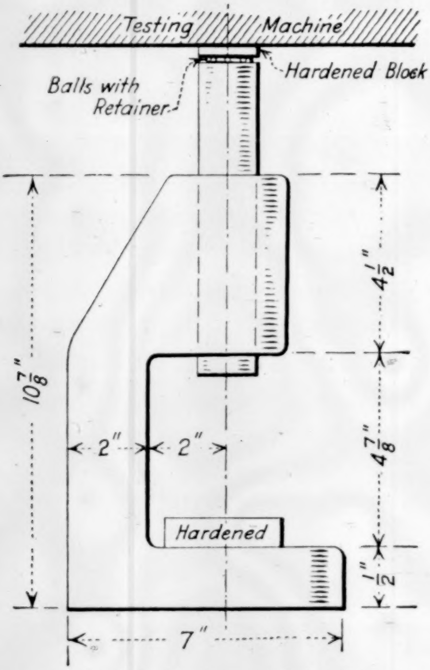

FIG. 3.—Compression Tool.

12. In making tests to determine the elastic limit in compression of metallic materials, the cross-head speed of the testing machine shall in no case exceed the allowable speed of head for the corresponding tension test of the material, as given in Sections 18 and 19 of the Tentative Methods of Tension Testing of Metallic Materials (Serial Designation: E 8 - 27 T) of the American Society for Testing Materials.[1]

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[1] See p. 1067.

THE DETERMINATION OF ELASTIC LIMIT, YIELD POINT, AND COMPRESSIVE STRENGTH

13. (*a*) The term "elastic limit" in compression is defined the same as in tension, as follows:

> *Elastic Limit.*—The greatest stress which a material is capable of developing without a permanent deformation remaining upon complete release of the stress.

(*b*) The same general methods for determining elastic limit, as given in Section 20 of the Tentative Methods of Tension Testing of Metallic Materials (Serial Designation: E 8 - 27 T) of the American Society for Testing Materials,[1] shall be used. For compression tests, Method II or a still more precise method seems generally suitable.

14. (*a*). The term "yield point" in compression is defined the same as in tension, as follows:

> *Yield Point.*—The stress in a material at which there occurs a marked increase in strain without an increase in stress.

(*b*) The same methods for determining yield point as given in Section 21 of the Tentative Methods of Tension Testing of Metallic Materials (Serial Designation: E 8 - 27 T)[1] shall be used. The method by the use of dividers or by the use of a strainometer seems generally suitable for compression testing.

15. The term "compressive strength" is defined as follows:

> *Compressive Strength.*—The maximum compressive stress which a material is capable of developing.

NOTE.—In the case of a material which fails in compression by a shattering fracture the compressive strength has a very definite value. In the case of materials which do not fail in compression by a shattering fracture the value obtained for compressive strength is an arbitrary value depending upon the degree of distortion which is regarded as indicating complete failure of the metal.

PLOTTING STRESS-STRAIN DIAGRAMS

16. The discussion and directions given in Section 25 of the Tentative Methods of Tension Testing of Metallic Materials (Serial Designation: E 8 - 27 T)[1] apply to plotting stress-strain diagrams for compression tests.

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[1] See p. 1067.

TENTATIVE REVISIONS
OF
A.S.T.M. STANDARDS

Tentative revisions of A.S.T.M. Standards are printed for one or more years with a view of eliciting criticism, of which the committee concerned will take due cognizance before recommending final action.

Members of the Society and others are invited to direct written criticisms of any of these Tentative Revisions to the officer of the appropriate committee, whose name and address appear in the footnote in connection with each revision.

TENTATIVE REVISIONS OF A.S.T.M. STANDARDS

A. FERROUS METALS

STANDARD SPECIFICATIONS FOR STEEL TRACK SPIKES

(Serial Designation: A 65 – 24)[1]

A revision in the form of separate tentative specifications entitled "Specifications for Soft Steel Track Spikes (A 65 – 26 T)"[2] is intended to replace the present standard specifications.

STANDARD SPECIFICATIONS FOR GRAY-IRON CASTINGS

(Serial Designation: A 48 – 18)[3]

Section 5. (*a*).—Change to read as follows by the addition of the italicized figures and the omission of those in brackets:

"The transverse test specimens (arbitration test bars) specified in Section 7 (a), when placed horizontally upon supports [12] *18* in. apart and tested under a centrally applied load, shall conform to the following minimum requirements, interpreted in accordance with Section 9:

	Class of Casting		
	Light	Medium	Heavy
"Load at center, lb.	[2500] *1500*	[2900] *1750*	[3300] *2000*
Deflection at center, in.	[0.10] *0.20*	[0.10] *0.20*	[0.10] *0.20*"

Figure 1.—Change the present Fig. 1, showing the arbitration est bar, referred to in Section 8, to conform to the accompanying Fig. 1.

Figure 2.—Change the present Fig. 2, showing the tension test specimen, referred to in Section 11, to conform to the accompanying Fig. 2.

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[1] 1927 Book of A.S.T.M. Standards, Part I. Criticisms of this revision are solicited and should be directed to Mr. G. H. Woodroffe, Secretary of Committee A-1 on Steel, Reading Iron Co., Reading, Pa.

[2] *Proceedings*, Am. Soc. Testing Mats., Vol. 26, Part I, p. 631 (1926); also 1927 Book of A.S.T.M. Tentative Standards, p. 21.

[3] 1927 Book of A.S.T.M. Standards, Part I. Criticisms of this revision are solicited and should be directed to Mr. Hyman Bornstein, Secretary of Committee A-3 on Cast Iron, Deere and Co., Moline, Ill.

STANDARD SPECIFICATIONS FOR CAST-IRON SOIL PIPE AND FITTINGS

(SERIAL DESIGNATION: A 74 – 18)[1]

Section 4.—Change to read as follows by the addition of the italicized figures and the omission of those in brackets:

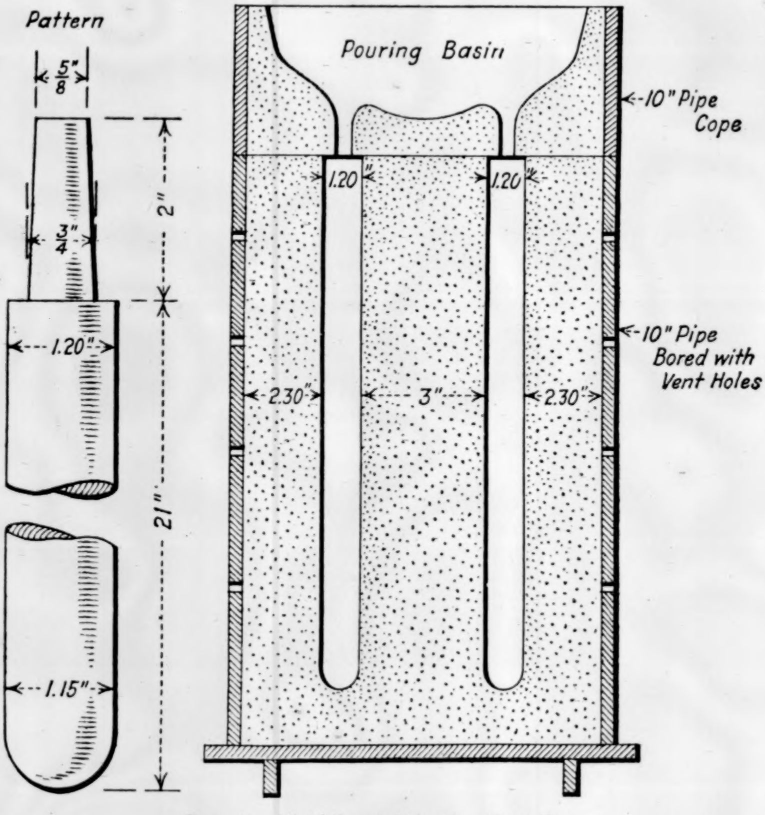

FIG. 1.—Mold for Arbitration Test Bar.

"The transverse test specimens (arbitration test bars) specified in Section 7, when placed horizontally upon supports [12] *18* in. apart and tested under a centrally applied load, shall conform to the following minimum requirements:

"Average load at center, lb........................ [2500] *1500*
Average deflection at center, in.................. [0.10] *0.20*"

Figure 1.—Change the present Fig. 1, showing the arbitration test bar, referred to in Section 4, to conform to the accompanying Fig. 1.

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[1] 1927 Book of A.S.T.M. Standards, Part I. Criticisms of this revision are solicited and should be directed to Mr. Hyman Bornstein, Secretary of Committee A-3 on Cast Iron, Deere and Co., Moline, Ill.

STANDARD SPECIFICATIONS FOR HIGH-TEST GRAY-IRON CASTINGS

(SERIAL DESIGNATION: A 88 - 24)[1]

Section 4 (a).—Change to read as follows by the addition of th italicized figures and the omission of those in brackets:

> "The transverse test specimens (arbitration test bars) specified in Section 6 (a), when placed horizontally upon supports [12] *18* in. apart and tested under a centrally applied load, shall withstand a minimum load of [3800] *2250* lb. and deflect under this load at least [0.12] *0.24* in. at the center."

Figure 1.—Change the present Fig. 1, showing the arbitration test bar, referred to in Section 6 (*a*), to conform to the accompanying Fig. 1.

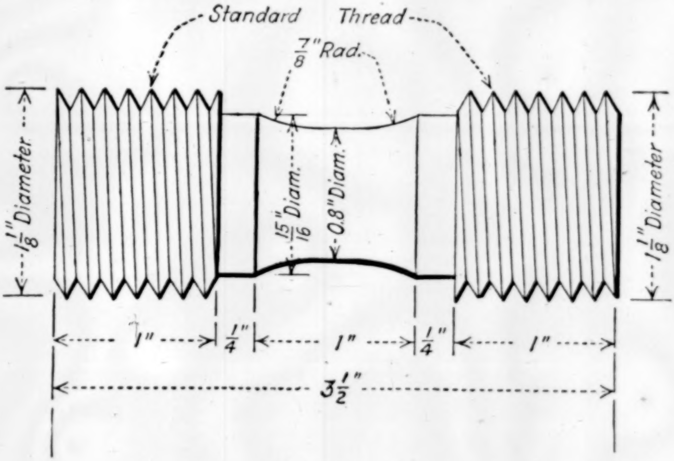

FIG. 2.—Tension Test Specimen.

Figure 2.—Change the present Fig. 2, showing the tension test specimen, referred to in Section 6 (*b*), to conform to the accompanying Fig. 2.

STANDARD METHODS OF TEST FOR MAGNETIC PROPERTIES OF IRON AND STEEL

(SERIAL DESIGNATION: A 34 - 27)[2]

A revision in the form of a separate tentative method of test entitled "Method of Test for Magnetic Properties of Iron and Steel at Low Inductions for Audio and Power Frequencies (A 34 - 27 T)"[3] is intended to be added as Method C to the present standard methods.

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[1] 1927 Book of A.S.T.M. Standards, Part I. Criticisms of this revision are solicited and should be directed to Mr. Hyman Bornstein, Secretary of Committee A-3 on Cast Iron, Deere and Co., Moline, Ill.

[2] 1927 Book of A.S.T.M. Standards, Part I. Criticisms of this revision are solicited and should be directed to Mr. R. L. Sanford, Secretary of Committee A-6 on Magnetic Properties, U. S. Bureau of Standards, Washington, D. C.

[3] See p. 698.

B. NON-FERROUS METALS

STANDARD SPECIFICATIONS FOR CARTRIDGE BRASS

(SERIAL DESIGNATION: B 19 – 19)[1]

Section 4.—Change the requirement for copper from "66.5–69.5 per cent" to "68.0–71.0 per cent."

Section 6.—Omit Paragraph (*a*) reading as follows, making Paragraph (*b*) appear as Section 6:

"Analyses of separate pieces may be made by the purchaser. The copper, lead, and iron contents thus determined shall be as follows:

Copper		66.0–70.0	per cent
Lead	not over	0.10	"
Iron	" "	0.08	"

Section 7.—Change the Brinell hardness limits from "51 to 65" to read "49 to 65." Omit the last sentence, reading as follows:

"No individual test shall exceed the limits of 50 to 69."

Add a note to this section, to read as follows:

"NOTE.—These specifications are intended to cover the requirements of commercial practice which do not in all cases agree with those of the Ordnance Department. These departures involve only the degree of final annealing."

STANDARD SPECIFICATIONS FOR CARTRIDGE BRASS DISKS

(SERIAL DESIGNATION: B 20 – 19)[1]

Section 3.—In Paragraph (*a*) change the gage tolerances to read as follows by the addition of the italicized figures and the omission of those in brackets:

Gage	Permissible Variation, in.
Up to 0.150 in., incl	[±0.0025] *−0, +0.0050*
Over 0.150 to 0.300 in., incl	[±0.003] *−0, +0.006*
Over 0.300 to 0.400 in., incl	[±0.004] *−0, +0.008*
Over 0.400 in	[±0.005] *−0, +0.010*

Add a new heading and a new section, to read as follows:

PHYSICAL PROPERTIES AND TESTS

4. The brass shall be so annealed that the average of ten Brinell hardness readings from a lot will be within the limits of 49 to 65, using a 10-mm. ball and a pressure of 500 kg.

NOTE.—These specifications are intended to cover the requirements of commercial practice which do not in all cases agree with those of the Ordnance Department. These departures involve only the degree of final annealing.

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[1] 1927 Book of A.S.T.M. Standards, Part I. Criticisms of this revision are solicited and should be directed to Mr. P. D. Merica, Secretary of Committee B-2 on Non-Ferrous Metals and Alloys, International Nickel Co., 67 Wall St., New York City.

STANDARD SPECIFICATIONS FOR SEAMLESS ADMIRALTY CONDENSER TUBES AND FERRULE STOCK

(SERIAL DESIGNATION: B 44 – 24)[1]

Section 12.—Insert under Sub-Heading IV on Permissible Variations in Dimensions, a new Section 12 to read as follows, renumbering the subsequent sections accordingly:

"12. *Diameter.*—The outside diameter of the tubes shall not vary from that specified by more than the following amounts, as measured by 'go' and 'no go' ring gages:

NOMINAL DIAMETER, IN.	PERMISSIBLE VARIATION, IN.
Up to 0.500, inclusive	plus or minus 0.002
Over 0.500 to 0.740, inclusive	" " " 0.0025
Over 0.740 to 1.000, "	" " " 0.003
Over 1.000 to 1.250, "	" " " 0.0035
Over 1.250 to 1.500, "	" " " 0.004"

C. CEMENT, LIME, GYPSUM AND CLAY PRODUCTS

STANDARD SPECIFICATIONS AND TESTS FOR PORTLAND CEMENT

(SERIAL DESIGNATION: C 9 – 26)[2]

A revision in the form of a separate tentative specification entitled "Specifications and Tests for Compressive Strength of Portland-Cement Mortars (C 9 – 16 T)"[3] is intended to become a part of the present standard specifications.

STANDARD SPECIFICATIONS FOR PAVING BRICK

(SERIAL DESIGNATION: C 7 – 15)[4]

A revision in the form of separate tentative specifications entitled "Specifications for Paving Brick (C 7 – 27 T)"[5] is intended to replace the present standard specifications.

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[1] 1927 Book of A.S.T.M. Standards, Part I. Criticisms of this revision are solicited and should be directed to Mr. P. D. Merica, Secretary of Committee B-2 on Non-Ferrous Metals and Alloys, International Nickel Co., 67 Wall St., New York City.

[2] 1927 Book of A.S.T.M. Standards, Part II. Criticisms of this revision are solicited and should be directed to Mr. F. H. Jackson, Secretary of Committee C-1 on Cement, U. S. Bureau of Public Roads, Washington, D. C.

[3] *Proceedings*, Am. Soc. Testing Mats., Vol. XX, Part I, p. 599 (1920); also 1927 Book of A.S.T.M. Tentative Standards, p. 189.

[4] 1927 Book of A.S.T.M. Standards, Part II. Criticisms of this revision are solicited and should be directed to Mr. J. W. McBurney, Secretary of Committee C-3 on Brick, U. S. Bureau of Standards, Washington, D. C.

[5] See p. 805.

STANDARD SPECIFICATIONS FOR HYDRATED LIME FOR STRUCTURAL PURPOSES

(SERIAL DESIGNATION: C 6 - 24)[1]

Section 12.—Change the second and fifth paragraphs from their present form: namely,

"The lime shall be made into a stiff putty with water and permitted to soak over night. It shall be molded in a rubber ring such as is used with a Vicat needle, resting the specimen on a glass plate."

"If the penetration is less than standard, the sample may be removed from the mold, mixed with more water, and retested. If the penetration is more than standard, the sample shall be discarded and a new one prepared."

to read respectively as follows:

"The lime shall be made into a stiff putty with water, stirred vigorously with a trowel or spatula for three minutes and permitted to soak over night. It shall be stirred vigorously with a trowel or spatula for three minutes, molded in a rubber ring such as is used with a Vicat needle, resting the specimen on a glass plate."

"If the penetration is less than standard, the sample may be removed from the mold, mixed with more water, stirred vigorously with a trowel or spatula for three minutes, and retested. If the penetration is more than standard, the sample shall be discarded and a new one prepared."

STANDARD SPECIFICATIONS FOR CEMENT-CONCRETE SEWER PIPE

(SERIAL DESIGNATION: C 14 - 24)[2]

Section 1.—Add the following footnote:

"*Caution.*—The consumer or purchaser is cautioned against using cement-concrete pipe where the sewage shows an acid reaction."

STANDARD METHOD OF TEST FOR SOFTENING POINT OF FIRE-CLAY BRICK

(SERIAL DESIGNATION: C 24 - 20)[3]

Section 4.—It is recommended that the angle of mounting of the cone be changed from 75 deg. to 82 deg.

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[1] 1927 Book of A.S.T.M. Standards, Part II. Criticisms of this revision are solicited and should be directed to Mr. H. C. Berry, Chairman of Committee C-7 on Lime, University of Pennsylvania, Philadelphia, Pa.

[2] 1927 Book of A.S.T.M. Standards, Part II. Criticisms of this revision are solicited and should be directed to Mr. E. S. Rankin, Secretary of Committee C-4 on Clay and Cement-Concrete Pipe, Bureau of Sewers, City Hall, Newark, N. J.

[3] 1927 Book of A.S.T.M. Standards, Part II. Criticisms of this revision are solicited and should be directed to Mr. L. J. Trostel, Secretary of Committee C-8 on Refractories, General Refractories Co. Laboratories, P. O. Box 935, Baltimore, Md.

Section 5 (*a*).—Change from its present form: namely,

"The heating shall be done in a suitable furnace at a rate not greater than 15° C. (27° F.) per minute, nor less than 10° C. (18° F.) per minute after cone No. 1 is reached, or as nearly within these limits as possible."

to read as follows:

"The heating shall be carried out in a suitable furnace at a rate to conform to the following requirements:

To reach cone 20	45	minutes
Time interval to cone 23	20	"
" " " " 26	6	"
" " " " 27	4	"
" " " " 28	4	"
" " " " 29	10	"
" " " " 30	4	"
" " " " 31	8	"
" " " " 32	4	"
" " " " 33	8	"
" " " " 34	18	"
" " " " 35	6	"

NOTE.—At 1000° C. the old cone pat may be removed and a new one put in without cooling the furnace down below red heat.

STANDARD DEFINITIONS FOR CLAY REFRACTORIES

(SERIAL DESIGNATION: C 27 – 20)[1]

Omit Section 3 comprising the reference to the test to be used for linear contraction or expansion, and Sections 5, 9, 11 and 13 covering the requirements in the case of clay brick, siliceous brick, intermediate duty brick and moderate duty brick, respectively. Renumber the remaining sections accordingly.

STANDARD DEFINITIONS OF TERMS RELATING TO THE GYPSUM INDUSTRY

(SERIAL DESIGNATION: C 11 – 26)[2]

Revisions in the form of tentative definitions of terms entitled 'Definitions of Terms Relating to the Gypsum Industry (C 11 – 27 T)"[3] are intended to become a part of the present standard definitions.

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[1] 1927 Book of A.S.T.M. Standards, Part II. Criticisms of this revision are solicited and should be directed to Mr. L. J. Trostel, Secretary of Committee C-8 on Refractories, General Refractories Co. Laboratories, P. O. Box 935, Baltimore, Md.

[2] 1927 Book of A.S.T.M. Standards, Part II. Criticisms of this revision are solicited and should be directed to Mr. H. J. Schweim, Secretary of Committee C-11 on Gypsum, The Gypsum Industries, 844 Rush St., Chicago, Ill.

[3] See p. 793.

D. MISCELLANEOUS MATERIALS

STANDARD SPECIFICATIONS FOR BROKEN SLAG FOR WATERBOUND BASE AND WEARING COURSE

(SERIAL DESIGNATION: D 65 – 23)[1]

Section 4.—Omit this section, reading as follows, renumbering the subsequent sections accordingly:

"The percentage of wear shall be not more than 12.0 per cent."

Section 6.—Change the last line of this section to read as follows by the addition of the italicized words and figures and the omission of those in brackets:

"[Retained on] *Passing* 2½-in. screen . . . not [less] *more* than [85] *15* per cent."

Section 7 (b).—Omit this paragraph which refers to the method of testing the percentage of wear.

STANDARD SPECIFICATIONS FOR SHOVEL-RUN OR CRUSHER-RUN BROKEN SLAG FOR WATERBOUND BASE

(SERIAL DESIGNATION: D 66 – 23)[1]

Section 4.—Omit this section, reading as follows, renumbering the subsequent sections accordingly:

"The percentage of wear shall be not more than 15.0 per cent."

Section 6 (b).—Omit this paragraph which refers to the method of testing the percentage of wear.

STANDARD SPECIFICATIONS FOR RUBBER BELTING FOR POWER TRANSMISSION

(SERIAL DESIGNATION: D 53 – 24)[2]

Section 11.—Change the last sentence to read as follows by the addition of the italicized figures and the omission of those in brackets:

"The rate of separation of the jaws shall be approximately [1½ to 4 in.] *½ to 2 in.* per minute."

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[1] 1927 Book of A.S.T.M. Standards, Part II. Criticisms of this revision are solicited and should be directed to Mr. Prévost Hubbard, Secretary of Committee D-4 on Road and Paving Materials, The Asphalt Association, 441 Lexington Ave., New York City.

[2] 1927 Book of A.S.T.M. Standards, Part II. Criticisms of this revision are solicited and should be directed to Mr. E. H. Grafton, Secretary of Committee D-11 on Rubber Products, Murray Rubber Co., Trenton, N. J.

Section 14.—In place of the ravel test at present specified, include a reference to the grab test as described in the Standard General Methods of Testing Woven Textile Fabrics (Serial Designation: D 39) of the American Society for Testing Materials.[1]

STANDARD SPECIFICATIONS FOR RUBBER PUMP VALVES

(SERIAL DESIGNATION: D 151 - 23)[2]

Section 4 (c).—Eliminate reference to reclaimed rubber.

STANDARD SPECIFICATIONS FOR ADHESIVE TAPE FOR GENERAL USE FOR ELECTRICAL PURPOSES

(SERIAL DESIGNATION: D 69 - 24)[2]

Title.—Change the word "adhesive" to "friction."

Section 1.—Change the first sentence to read as follows by the addition of the italicized word and the omission of those in brackets:

> "These specifications cover commercial [adhesive] *friction* tape [(also called 'friction' tape)] consisting of strips of cotton sheeting impregnated with an adhesive insulating compound."

Section 7.—In the first sentence, change the words "strong light" to "window light."

Section 9.—Change Paragraph (*a*) from its present form: namely,

> "The adhesion between adjacent layers of the tape shall be such that when a strip of tape 2 ft. long is taken from a roll and wound upon a mandrel 1 in. in diameter under a tension of 10 lb. per inch of width at a rate of 30 in. per minute, and allowed to stand for three minutes with the weight attached, a weight of 4 lb. per inch of width shall not cause the plies to separate at a rate greater than 30 in. per minute.
>
> "The test shall be made at a room temperature not less than 21.1° C. (70° F.) nor more than 23.9° C. (75° F.), the sample having been kept within these limits for at least 30 minutes immediately preceding the time of testing.
>
> "The mandrel shall be so free in its bearings that a weight of 1 oz. will cause it to revolve freely when suspended from a cotton string wound in a single layer on the center of the mandrel."

to read as follows:

> "The adhesion between adjacent layers of the tape shall be determined as follows: A sample 23 in. long shall be removed from the roll, care being taken not to touch the surface to be tested with the hands or otherwise. Two inches of the sample shall be wound on the mandrel described below and a weight of 10 lb. per in. of width of the tape shall be attached to the end of the sample

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[1] 1927 Book of A.S.T.M. Standards, Part II.

[2] 1927 Book of A.S.T.M. Standards, Part II. Criticisms of this revision are solicited and should be directed to Mr. E. H. Grafton, Secretary of Committee D-11 on Rubber Products, Murray Rubber Co., Trenton, N. J.

and 19 in. of the sample wound onto the mandrel at a uniform rate of 12 in. per minute. The tape shall be allowed to stand for three minutes with the weight attached after which a weight of 4 lb. per inch of width shall be substituted for the weight of 10 lb. per inch of width, and the tape allowed to unwind. After 2 in. have unwound, the rate of unwinding shall not be greater than 15 in. in one minute.

"The temperature of the room and the temperature of the tape shall be not less than 20° C. (68° F.) nor more than 22.2° C. (72° F.)

"The mandrel used shall be ¼ in. in diameter and shall be mounted in a level position in Fafnir Bearing Co. ball bearings, Catalog No. 0.096, or equivalent ball bearings. The mandrel shall turn freely under the weight of 5 g., suspended from a cotton thread wound in a single layer on the center of the mandrel."

Section 12.—In the first column of the table appearing in this section, add the word "nominal" before the word "thickness."

STANDARD METHODS OF TESTING OLEO-RESINOUS VARNISHES

(SERIAL DESIGNATION: D 154 – 25)[1]

A revision in the form of a separate tentative method of test entitled "Method of Test for Elasticity or Toughness of Varnishes by Means of Addition of Linseed Oil (D 154 – 26 T)"[2] is intended to become a part of the present standard methods.

STANDARD METHODS OF TESTING SHELLAC

(SERIAL DESIGNATION: D 29 – 25)[1]

A revision in the form of a separate tentative method of test entitled "Method of Test for Determination of Wax in Shellac ('Machine-Made' and Dry-Bleached Refined Shellac) (D 29 – 27 T)"[3] is intended to be added to the present standard methods.

STANDARD METHODS OF LABORATORY SAMPLING AND ANALYSIS OF COAL AND COKE

(SERIAL DESIGNATION: D 271 – 27)[4]

A revision in the form of separate tentative methods entitled "Methods for the Determination of Sulfur in Coal and Coke by the Bomb-Washing and Sodium Peroxide Fusion Methods (D 271 – 27 T)"[5] is intended to be added to the present standard methods.

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[1] 1927 Book of A.S.T.M. Standards, Part II. Criticisms of this revision are solicited and should be directed to Mr. R. L. Hallett, Secretary of Committee D-1 on Preservative Coatings for Structural Materials, National Lead Co., 105 York St., Brooklyn, N. Y.

[2] *Proceedings*, Am. Soc. Testing Mats., Vol. 26, Part I, p. 814 (1926); also 1927 Book of A.S.T.M. Tentative Standards p. 331.

[3] See p. 869.

[4] 1927 Book of A.S.T.M. Standards, Part II. Criticisms of this revision are solicited and should be directed to Mr. W. A. Selvig, Secretary of Committee D-5 on Coal and Coke, U. S. Bureau of Mines, 4800 Forbes St., Pittsburgh, Pa.

[5] See p. 959.

STANDARD METHODS OF TESTING MOLDED INSULATING MATERIALS

(SERIAL DESIGNATION: D 48 - 27)[1]

Section 15.—Change from its present form: namely,

"The test specimen shall be molded to the dimensions shown in Fig. 4. The mold shall be hardened and ground to these dimensions. If the material cannot be molded to the full height shown, the height may be reduced to 1¼ in. (31.7 mm.).

"For materials having a puncture value higher than 300 volts per mil, the thickness of the bottom of the specimen may be reduced to 0.098 in. (2.5 mm.). It should be noted, however, that the apparent dielectric strength in volts per mil may be increased as much as 50 per cent when the thickness of the bottom of the specimen is so reduced."

to read as follows:

"The test specimen shall be molded in the form of a disk 4 in. (10.16 cm.) in diameter which should be ⅛ in. (3.175 mm.) in thickness for hot molded materials and ¼ in. (6.35 mm.) in thickness for cold molded materials."

Section 16.—Change Paragraph (*a*) from its present form: namely,

"(*a*) Voltage shall be applied to the test specimen by floating the specimen on mercury and placing a pool of mercury about ⅛ in. (3 mm.) deep inside the specimen.

"It is recommended that all tests be made in air, but whenever it is impossible to puncture the specimen in air without arcing over the edge, it shall be immersed in high grade transformer oil. On specimens which require a very high voltage to puncture, it may be necessary to put a glass tube or shield over the wire leading to the mercury on the inside of the specimen in order to prevent breakdown over the surface of the oil between terminals. The testing voltage shall be raised at a constant rate of approximately one thousand volts per second until puncture occurs."

to read as follows:

"Voltage shall be applied to the test specimen by means of two flat electrodes 1 in. in diameter with edges rounded to a radius of ⅛ in. These electrodes shall be placed directly opposite each other at the center of the specimen.

"It is recommended that all tests on hot molded materials be made under oil and tests on cold molded materials in air. Testing voltage shall be raised at a constant rate of approximately 1000 volts per second until a puncture occurs."

Omit Paragraph (*c*) reading as follows:

"(*c*) The results from specimens where puncture takes place up on the side of the specimen instead of through the bottom shall be discarded. Experience shows that very plastic materials which flow easily in the mold always puncture through the bottom, while materials which do not mold readily will often puncture through the side walls of the specimen at some distance up from the bottom."

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[1] 1927 Book of A.S.T.M. Standards, Part II. Criticisms of this revision are solicited and should be directed to Mr. T. S. Taylor, Secretary of Committee D-9 on Electrical Insulating Materials, Bakelite Corporation, 230 Grove St., Bloomfield, N. J.

Section 17 (a).—Change from its present form: namely,

"The thickness of the bottom of each specimen measured with a micrometer in the direction perpendicular to the bottom surface, and also the thickness at the point of puncture, regardless of the path taken by the discharge. The thickness of each specimen shall be given in mils or in millimeters."

to read as follows:

"The thickness of each specimen shall be given in mils or millimeters."

Figure 4.—Omit this figure.

STANDARD DEFINITIONS OF TERMS RELATING TO PAINT SPECIFICATIONS

(SERIAL DESIGNATION: D 16 - 24)[1]

Add the following three new definitions of terms:

Toughness.—Relative degree of resistance to impact without fracture; apposed to brittleness.

Elasticity of Paint and Varnish Films.—That property which allows a paint or varnish film to follow, without rupture, changes in the extent and form of the surface to which it is applied.

"*Screen (Sieve).*—A plate or sheet or woven cloth with regularly spaced apertures of uniform size, mounted on a suitable frame or holder, for use in separating materials according to size."

"NOTE.—The shape and spacing of apertures, size of wires or threads, thickness of plate or sheet, allowable variations and similar properties should be described in the specifications."

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[1] 1927 Book of A.S.T.M. Standards, Part II. Criticisms of this revision are solicited and should be directed to Mr. R. L. Hallett, Secretary of Committee D-1 on Preservative Coatings for Structural Materials, National Lead Co., 105 York St., Brooklyn, N. Y.

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